K.3

MATRA MARCONI SPACE	METOP	Ref : MMS/MET/TN/JLD/160.94 Issue : 2 Rev.: 0 Date : September 1993 Page : i

Title

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINES

	Name and Function	Date	Signature
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FOREWORD

The METOP documentation, related to the instrument interfaces consists of the following two documents :

- the General Instrument Interface Control Document (GICD - DRD - 21).

  This document aims at defining all the requirements on the interfaces, tests and programme to which all the instruments shall comply for the METOP mission. It is a generic specification, applicable to any of the METOP payload complement instruments, that deals with interfaces from the platform towards the instruments.

- The Instrument Interface Control Document (ICD) Outlines (DRD - 22).

  This document gathers each individual instrument ICD outline that defines the technical and programmatic interface information applicable to a particular instrument. It these deals with interfaces from the instruments towards the platform, and with the instrument responses to the generic GICD (DRD - 21).

Both documents have been elaborated by MATRA MARCONI SPACE along with DORNIER and MMS space systems, Ltd.

TABLE OF CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

The Instrument Interface Control Document (ICD) Outlines document defines the interfaces of each of the instruments the METOP platform shall accommodate. It then deals with requirements from the instrument towards the platform, and with responses of the instruments to the General Instrument Interface Control Document (GICD).

It aims at gathering in a single document the instrument related information that have been accounted for the METOP platform design. In a general way, this information has been provided by the relevant documentation (mainly Interface Documentation) provided by ESA in the frame of the METOP Phase A, completed by further elements received from ESA (e.g. telefax, letter, additional documents, outcomes from the Working Meetings.. .). Hence this document is this only METOP document that clearly defines all the instrument interfaces. Note however that the level of information corresponds to the current definition status of the system (Phase A), and so does not address in detail the instrument interfaces.

This issue presents the interface information for the following instruments :

Advanced Very-High Resolution Radiometer	AVHRR/3
High Resolution Infra-Red Sounder	HIRS/3
Advanced Microwave Sounding Unit - Al	AMSU-Al
Advanced Microwave Sounding Unit - A2	AMSU-A2
Microwave Humidity Sounder	MHS
Data Collection System	DCS/2
Infrared Atmospheric Sounding Interferometer	IASI
Advanced Scatterometer	ASCAT
Multi-frequency lmagmg Microwave Radiometer	MIMR
Scanner for Radiation Budget	SCARAB
Global Ozone Monitoring Experiment	GOME

1.2. OVERALL METOP PROGRAMME

The METOP satellite is an element of the EPS/METOP system, that will be jointly developed by ESA and EUMETSAT. This system mission objectives are operational meteorology and climate monitoring from polar orbit, in order to complement the NOAA Polar Orbiting Environmental Satellite System.

The METOP satellite is composed of a platform (or spacecraft) and a set of instruments constituting the payload. This comprises :

Operational Meteorological Package

* Advanced Very-High Resolution Radiometer	AVHRR/3
* High Resolution Infra-Red Sounder	HIRS/3
* Advanced Microwave Sounding Unit - A	AMSU-Al/A2
* Microwave Humidity Sounder	MHS
* Data Collection System	DCS/2
* Infrared Atmospheric Sounding Interferometer	IASI

- Climate Monitoring Payload

* Advanced Scatterometer	ASCAT
* Multi-frequency Imaging Microwave Radiometer	MIMR
* Scanner for Radiation Budget	SCARAB
* Global Ozone Monitoring Experiment	GOME

Note that the METOP programme comprises a series of two satellites : the first one is scheduled for an ARIANE 4 launch in late 2000, and the second one will be launched in line with the operational needs.

1.3. REFERENCE DOCUMENTATION

AD 1 MMS/MET/SPE/JLD/159.94 — General Instrument Interface Control Document (GICD) Issue 2, September 1994

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

The Instrument Interface Control Document (ICD) Outlines document defines the interfaces of each of the instruments the METOP platform shall accommodate. It then deals with requirements from the instrument towards the platform, and with responses of the instruments to the General Instrument Interface Control Document (GICD).

It aims at gathering in a single document the instrument related information that have been accounted for the METOP platform design. In a general way, this information has been provided by the relevant documentation (mainly Interface Documentation) provided by ESA in the frame of the METOP Phase A, completed by further elements received from ESA (e.g. telefax, letter, additional documents, outcomes from the Working Meetings...). Hence this document is this only METOP document that clearly defines all the instrument interfaces. Note however that the level of information corresponds to the current definition status of the system (Phase A), and so does not address in detail the instrument interfaces

This issue presents the interface information for the following instruments :

- Advanced Very-High Resolution Radiometer	AVHRR/3
- High Resolution Infra-Red Sounder	HIRS/3
- Advanced Microwave Sounding Unit - Al	AMSU-A 1
- Advanced Microwave Sounding Unit - A2	AMSU-A2
- Microwave Humidity Sounder	MHS
- Data Collection System	DCS/2
- Infrared Atmospheric Sounding Interferometer	IASI
- Advanced Scatterometer	ASCAT
- Multi-frequency Imaging Microwave Radiometer	MIMR
- Scanner for Radiation Budget	SCARAB
- Global Ozone Monitonng Espenment	GOME

2. INSTRUMENT INTERFACE SYNTHESIS

2.1. INSTRUMENT BUDGETS

Mass and Power Budgets

The instrument resources in terms of mass and power are summarized in Table 2. 1/1 The quoted values identify the system contingency considered for each instrument for the spacecraft overall dimensioning. This contingency has been forced to zero for IASI mass, MIMR mass, MIMR power and SCARAB power, as these values are assumed to already include a margin.

Note that no additional margin will be considered on top of this value in the frame of the METOP system activities.

Data Rate Budgets

METOP data rates are presented in Table 2.1/2. It identifies the different generated data streams in order to comply with the meteorological service requirements. The proposed budgets consists of packetized data rates.

2.2. INSTRUMENT INDUCED DISTURBANCE STATUS

A status on the available data is presented in Table 2.2/1

2.3. THERMAL INTERFACES

The main instrument thermal characteristics are illustrated in Table 2.3/1

2.4. ELECTRICAL INTERFACES

The connection concept between the instruments and the platform is illustrated in Figures 2.4/1 and 2.4/2 respectively for the NOAA K,L,M instruments, i.e. AVHRR/3, HIRS/3, AMSU-Al, AMSU-A2 and DCS/2, and for the European instruments, i.e. MHS, IASI, ASCAT, MIMR, SCARAB and COME.

NAME	UNIT	BASIC MASS ER UNIT kg	BASIC MASS TOTAL kg	CONT.	CURRENT MASS ER UNIT kg	CURRENT MASS TOTAL kg	BASIC POWER ER UNIT W	BASIC POWER TOTAL W	CONT.	CURRENT POWER ER UNIT W	CURRENT POWER TOTAL W
AVHRR/3	AVHRR/3	31.300	31,300	5%	32865	32,865	26,400	26,400	10%	29,040	29,040
HIRS/3	HIRS/3	33.100	33,100	5%	34.755	34,755	22,800	22,800	10%	25,080	25,080
AMSU-A1	AMSU-A1	53,300	53,300	5%	55,965	55,965	88,300	88,300	10%	97,130	97,130
AMSU-A2	AMSU-A2	47,400	47,400	5%	49,770	49,770	37,250	37,250	10%	40.975	40,975
MHS	MHS	60,000	60,000	10%	66,000	66,000	90,000	90,000	11%	100,000	100,000
DCS/2	RPU	13,800	39,000	5%	14.490	40,950	TBD	27,445	10%	TBD	30,190
	SPU-A	12,600			13.230		TBD			TBD	
	SPU-B	12,600			13.230		TBD			TBD	
IASI	Sensor	99,800	147,600	0%	99,800	147,600	74,000	196,000	10%	81.400	215,600
	Main Elect	27,300			27,300		62,000			68,200	
	Secondary Elm	20,500			20,500		60,000			66,000	
ASCAT	Mid Antenna	22,300	190,370	10%	24,530	212,717		262,384	10%		288,622
	Mid Ant. Sup. Struct.	7,000		10%	7.700						
	Side Ant. Right Fore	29,200		10%	32,120						
	H&Depl. Syst. ANTRF	9.700		20%	11.640						
	Side Ant. Right Aft	29,200		10%	32120						
	H&Depl. Syst. ANTRA	12,800		20%	15.360						
	SFE	13.990		10%	15,389		13,000			14,300	
	HPA-SSPA+red.	4.600		10%	5,060		117,540			129,294	
	HPA-EPC+red.	6,760		10%	7.436		50,210			55,231	
	RFU+red.	12,000		10%	13,200		Pal			24.860	
	DPU+red.	13,600		10%	14,960		23,300			25,630	
	ICU+red.	13,000		10%	14,300		17,500			19,250	
	PDU	3,260		10%	3,586		15.870			17.457	
	WR Run	2,600		20%	3.120						
	WGS	0,860		10%	0.946		0,000			0,000	
	DPE	1,500		10%	1,650						
	Harness	8.000		20%	9.600		2364			2,600	
MIMR	Sensor	146,400	160,000	0%	146,400	160,888	82,500	171,000	0%	82,500	171,000
	MCU	3,600			3.600		70,000			70,000	
	ICPU+red.	7,000			7,000		10,500			10,500	
	LVPS+red.	3,000			3,000		8,000			8,000	
SCARAB	SCARAB	50,000	50,000	20%	60,000	60,000	75,000	75,000	0%	75,000	75,000
GOME	GOME	56,000	56,000	5%	58,800	58,800	42,000	42,000	5%	44,100	44,100
TOTAL			868,1 kg			919.4 kg		1038,6 W			1116,7 W

Figure 2.1/1 : METOP Instrument Resource Summary (Mass and Power)

NAME	LRPT kbps	HRPT-I kbps	HRPT-Q kbps	GLOBAL DATA kbps
AVHRR/3	37.968	621.984	-	62 1.984
HIRS/3	2.898	2.898		2,898
AMSU-Al	1.258	1.258	-	1.258
AMSU-AZ	0.330	0,330		0.330
MHS	3,840	3.840	-	3.840
DCS/2	2.560	2.560		2.560
IASI		-	1500.000	1500.000
ASCAT	-	43.530		43.530
MIMR		-	112.000	112.000
SCARAB		3.000		3.000
COME		-	50.000	50.000
HK Data	4.096	4.096		4.096
Adm. Message	2.000	2.000	2.000	
TOTAL	54,9 kbps	685,5 kbps	1664,0 kbps	2345.5 kbps

Figure 2.1/2 : METOP Data Distribution Service (Packetized Data Rate Budgets)

Instrument	Disturbing Source	Provided Data	Missing Data
AVHRR/3	Continuous scanning	Kinetic momentum	Scan axis torque Unbalance effects
HIRS/3	Step scanning	Kinetic momentum	Scan axis torque Unbalance effects
AMSU-A1	Step scanning	Torque profile	Unbalance effects
AMSU-A2	Step scanning	Residual torque profile	Unbalance effects
MHS	Step scanning	Residual torque profile	Unbalance effects
IASI	Scan mirror motion Cube corners motion	Scan axis torque Induced forces	Unbalance effects -
MIMR	Continuous scanning	Unbalance effects	-
SCARAB			Unbalance effects
GOME	Scanning	Peak torque and angular momentum amplitude	Frequency content and / or time plot

Figure 2.2/1: METOP Instrument Induced Disturbances Summary and Status

NAME	UNIT	THERMAI CONTROI CONCEPT	ACCEPTANCE Operating °C	Non-Operatin °C	MPERATU Switch-On °C	Stability °C/h	DISSIPATED POWER W	ADIATOR	REQUIRED SIDE CCOMMODATION
AVHRR/3	AVHRR/3	C	10/30	0/30	0	2	TBD	YE	Anti-Sun
HIRS/3	HIRS/3	C	5/25	-10/30	-10	5	TBD	Yes	Anti-Sun
AMSU-A1	AMSU-A1	A	8/28	-30/66	-20	NO	TBD	Yes	Velocity Preferred
AMSU-A2	AMSU-A2	A	6/28	-30/66	-20	NO	TBD	Yes	Velocity Preferred
MHS	MHS	A	-5/30	-0.5	-10	NO	TBD	Yes	
DCS/2	RPU	B	-5/45	-30/60	-10	NO	30 Total	NO	
	SPU-A	B	-5/45	-30/60	-10	NO		NO	
	SPU-B	B	-5/45	-30/60	-10	NO		No	
IASI	Sensor Module	A	10/30	-40/60	-40	No	TBD	Yes	Anti-Sun
	Main Elect. Modul	A	-40/60	-40/60	-30	No	TBD	Yes	Anti-nadir
	Secondary Elec. M	A (B poss.	-40/60	-40/60	-30	NO	TBD	Yes	Anti-nadir
ASCAT	Mid Antenna	A	TBD	TBD	TBD	NO	TBD		
	Side Ant. Right For	A	TBD	TBD	TBD	NO	TBD		
	Side Ant. Right Aft	A	TBD	TBD	TBD	No	TBD		
	SFE	A	TBD	TBD	TBD	NO	20	TBD	
	SSPA+red.	B	-5/40	-30/70	-25	NO	83	No	
	EPC+red.	B	-5/40	-30/70	-25	NO	55	NO	
	RFU+red.	B	-5/40	-30/70	-25	NO	25	No	
	DPU+red.	B	-5/40	-40/70	-25	No	26	No	
	ICU+red.	B	-10/50	-40/70	-25	NO	19	No	
	PDU	B	-10/50	-40/70	-25	NO	17	No	
	DPE	B	TBD	TBD	TBD	No	eployment Or	NO	
	WG	B	TBD	TBD	TBD	NO	0	No	
	Harness								
MIMR	Sensor Module	A	TBD	TBD	TBD	TBD	TBD	Yes	Velocity
	MCU	B	TBD	TBD	TBD	TBD	m	No	
	ICPU+red.	B	TBD	TBD	TBD	TBD	II	No	
	LVPS+red.	B	TBD	TBD	TBD	TBD	8	No	
SCARAB	SCARAB	A	TBD	TBD	TBD	TED	TBD	TBD	
GOME	GOME	A	TBD	TBD	TBD	TBD	42 TBC	Yes	Velocity

Figure 2.3/1: METOP Instrument Thermal Interface Summary

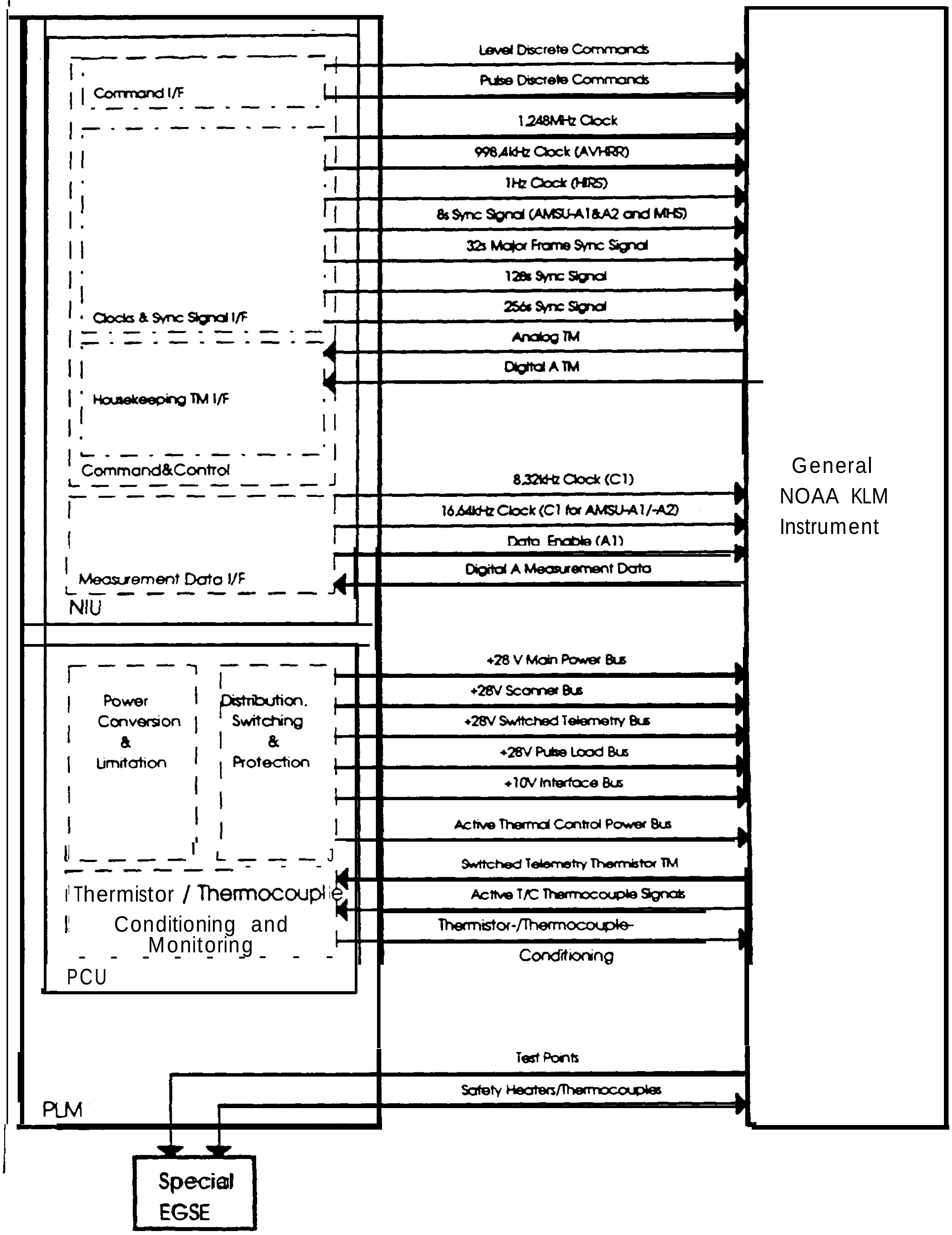


Figure 2.4/1 : Electrical Interfaces of NOAA K,L,M Instruments

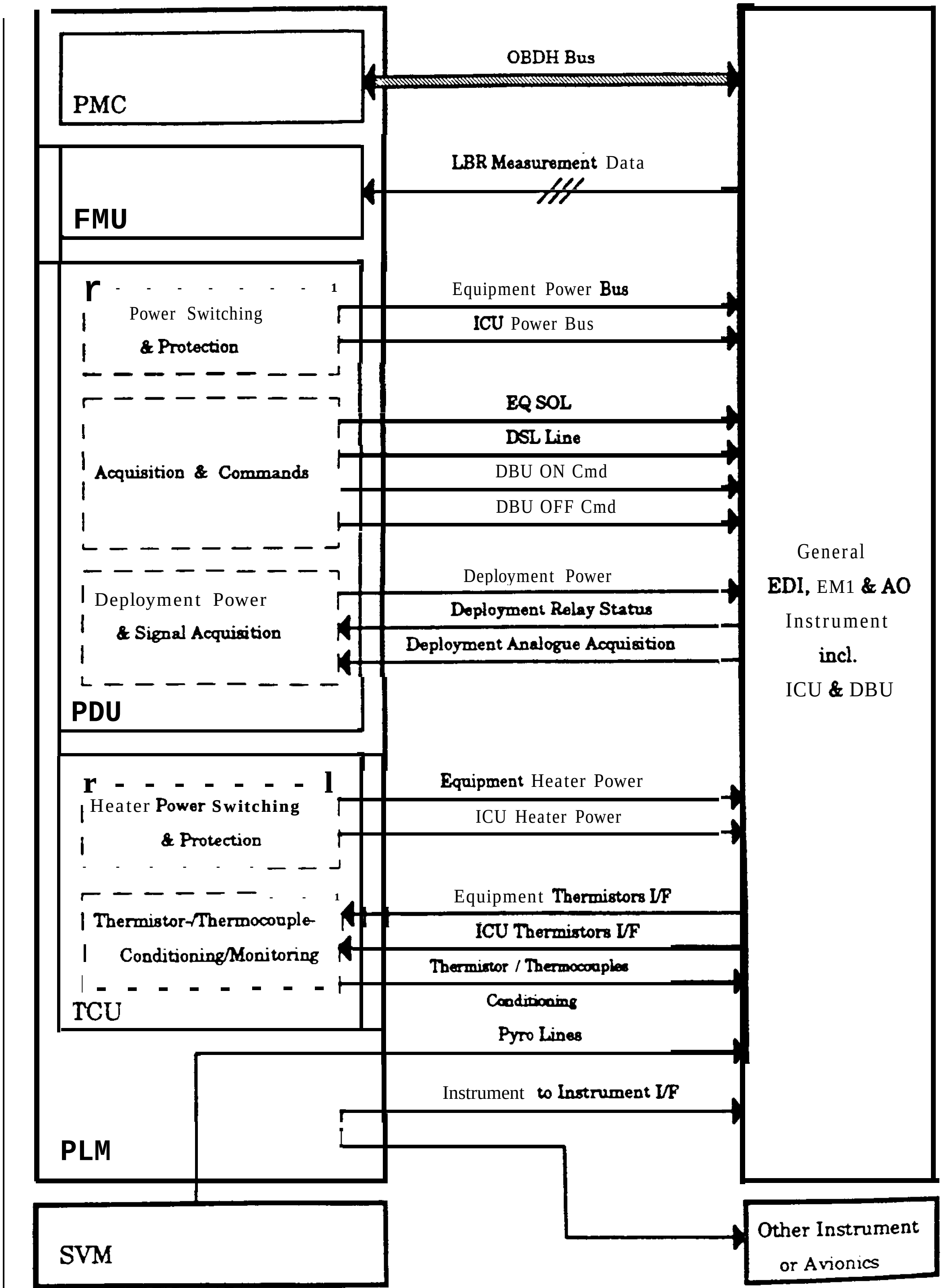


Figure 2.4/2 : Electrical Interfaces of EMI, EDI and AO instruments

2.5. MECHANICAL AND STRUCTURAL TEST STATUS

A status of the tests required on the METOP instruments is illustrated in Table 2.5/1. It takes into account the qualification of some instruments by previous programmes (Cf. relevant ICD for explanation and details).

Instrument	Quasi-Static Tests	Dynamic Model Validation	High Level Sine	Sine Burst	Random	Shock	Acoustic
AVHRR/3					Acc. TBC	X	
HIRS/3					Acc. TBC	X	
AMSU-A1					Qual.	X	
AMSU-A2	X	X	X		Qual.	X	
MHS					Qual.	X	
DCS/2					Acc.	X	
IASI				X	Qual.	X	
ASCAT	X	X	X		Qual.	X	X
MIMR	X	X	X		Qual.	X	X
SCARAB				X	Qual.	X	
GOME	X	X	X		Acc.	X	

Figure 2.5/1 : METOP Instrument Mechanical Test Requirement Status (TBC)

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

AVHRR/3

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the AVHRR/3 lnstnunent Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with AVHRR/3 responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

The Advanced Very High Resolution Radiometer, AVHRR/3, scans the Earth surface in six spectral bands in the range of 0.7 - 12 microns. It provides day-night imaging of land, water and clouds, measures sea surface temperature, ice, snow and vegetation cover and characteristics.

AVHRR/3 has an instant foot print in nadir of 1.1 km. Scanning is cross-track with a total field of view of ± 56 deg. about nadir. Instrument detectors are passively cooled to less than 100 K. The instrument uses an internal rotational scanning mirror which also views deep space and an internal calibration source.

	Central Wavelength (μm)	Half Power Points (μm)	Channel Noise Specifications	Time Availability Requirements
1	0.630	0.580 - 0.680	S/N 9:1 @ 0.5% albedo	24 hours
2	0.862	0.725 - 1.000	S/N 9:1 @ 0.5% albedo	24 hours
3a	1.610	1.580 - 1.640	S/N 20: 1 @ 0.5 % albedo	Day
3b	3.740	3.550 - 3.930	0.12K @ 300K	Night
4	10.800	10.300 - 11.300	0.12K @ 300K	24 hours
5	12.000	11.500 - 12.500	0.12K @ 300K	24 hours

Scan Type :	Continuous
scan Rate (s) :	0.1667
IFOV (deg.) :	0.0745 (square)
Earth View Pixels per Scan :	2048
Swath (deg. with respect to the nadir direction)	± 55.37 deg.

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94. Iss. 2. dated Sept. 94

Reference Documentation

Unique Interface Specification for the AVHRR/3
Ref. IS-20029950 (MET0020). dated January 1992
To be replaced by Rev. A. July 93 for future phase.

Performance Assurance Requirements for the NOAA-K, L & M AVHRR/3 and HIRS/3
Ref. S-480-29.1 (MET0154), dated March 1990, rev. G

Outline Drawing - AVHRR/3 Instrument
Ref. 8 157456 (MET0509), dated November 1993

Thermal Interface Drawing AVHRR/3
Ref. 8 157457 (MET0510), dated November 1993

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

AVHRR/3 is comprised of five modules (scanner, electronic, radiant cooler, optical subsystem and baseplate unit modules), which are assembled together into a single unit instrument.

The Part Number and Identification Code of the AVHRR/3 instrument are :

PART NO : T B D

ID CODE : TBD

The location of the labels giving these Part Numbers and Identification Codes are defined in the Mechanical Interface Control Drawing.

The stowed envelope is : L (Velocity) x W x H (Earth) 796 x 364 x 292 mm.
(31.33 x 14.35 x 11.5 in.)

The in-orbit configuration is reached as soon as the top radiator cover is open.

The deployed envelope is then : L (Velocity) x W x H (Earth) 796 x 5 19 x 292 mm

2.1.2. Mechanical Interface Control Drawing

The AVHRR/3 instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The AVHRR/3 stowed and deployed configurations are illustrated in Figures 2.1/1, 2.1/2 and 2.1/3.

2.1.3. Mass Properties

Mass

The mass properties of the AVHRR/3 instrument are given in the following table. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{AVHRR} , *with the origin being* at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing). The directions of the F_{AVHRR} axes are the same as the Spacecraft Reference Frame F_S. The AVHRR/3 centre of gravity location has been measured without the blankets.

Module /Unit	**Basic Mass (± TBD kg)**	**Centre of Mass Location (± 50 mm)**		
		X_{AVHRR} (Sun)	Y_{AVHRR} (Anti-velocity)	Z_{AVHRR} (Zenith)
AVHRR/3 stowed	31.3 kg (69 lb)	+ 123.4 mm (4.86 in)	+ 391.2 mm (15.40 in)	- 118.4 mm (4.66 in)
AVHRR/3 Deployed	31.3 kg (69 lb)	+ 122.7 mm (4.83 in)	+ 391.2 mm (15.40 in)	-120.1 mm (4.73 in)

AVHRR/3 Mass Properties

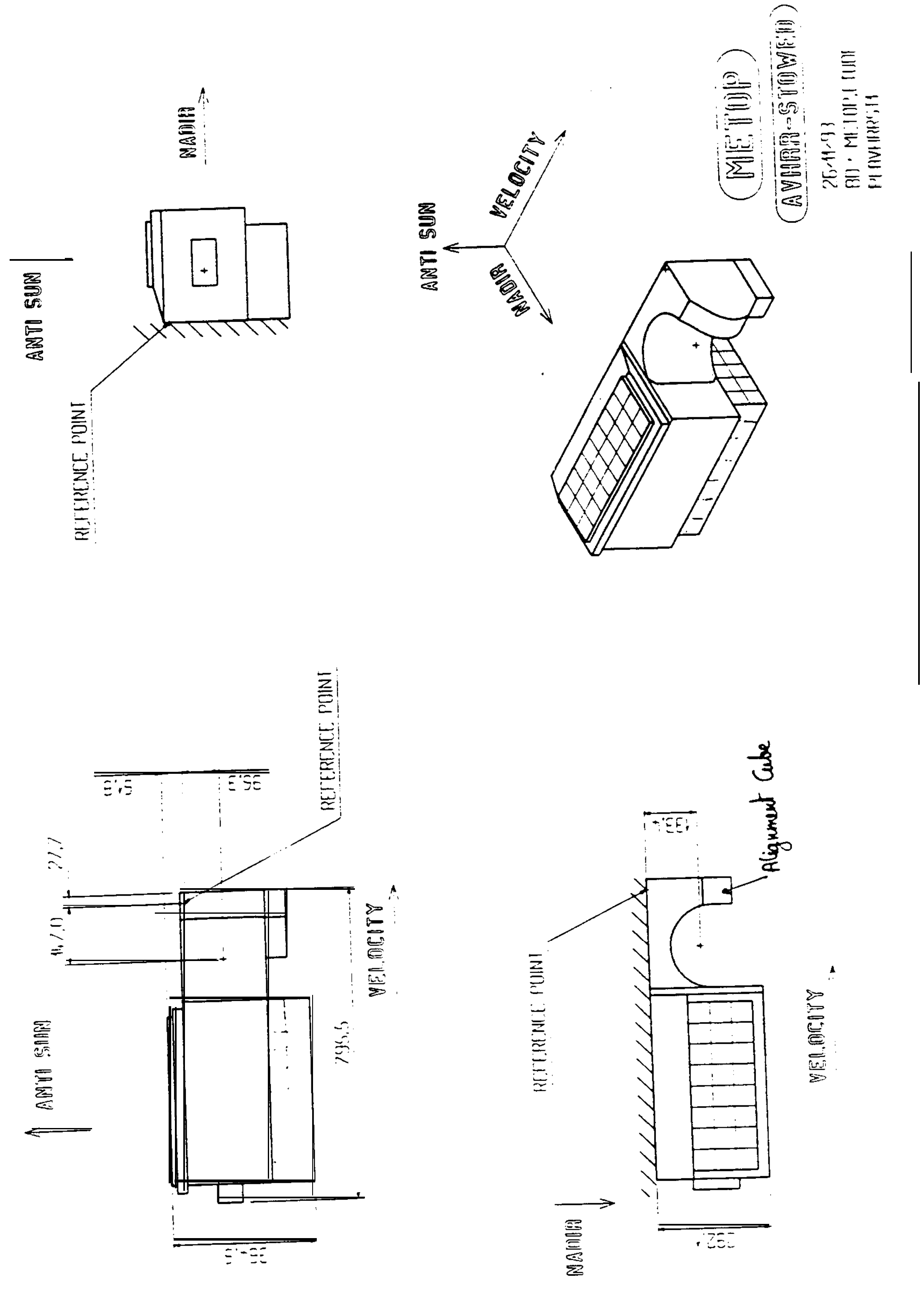


Figure 2.1/1 : AVHRR/3 Stowed Configuration

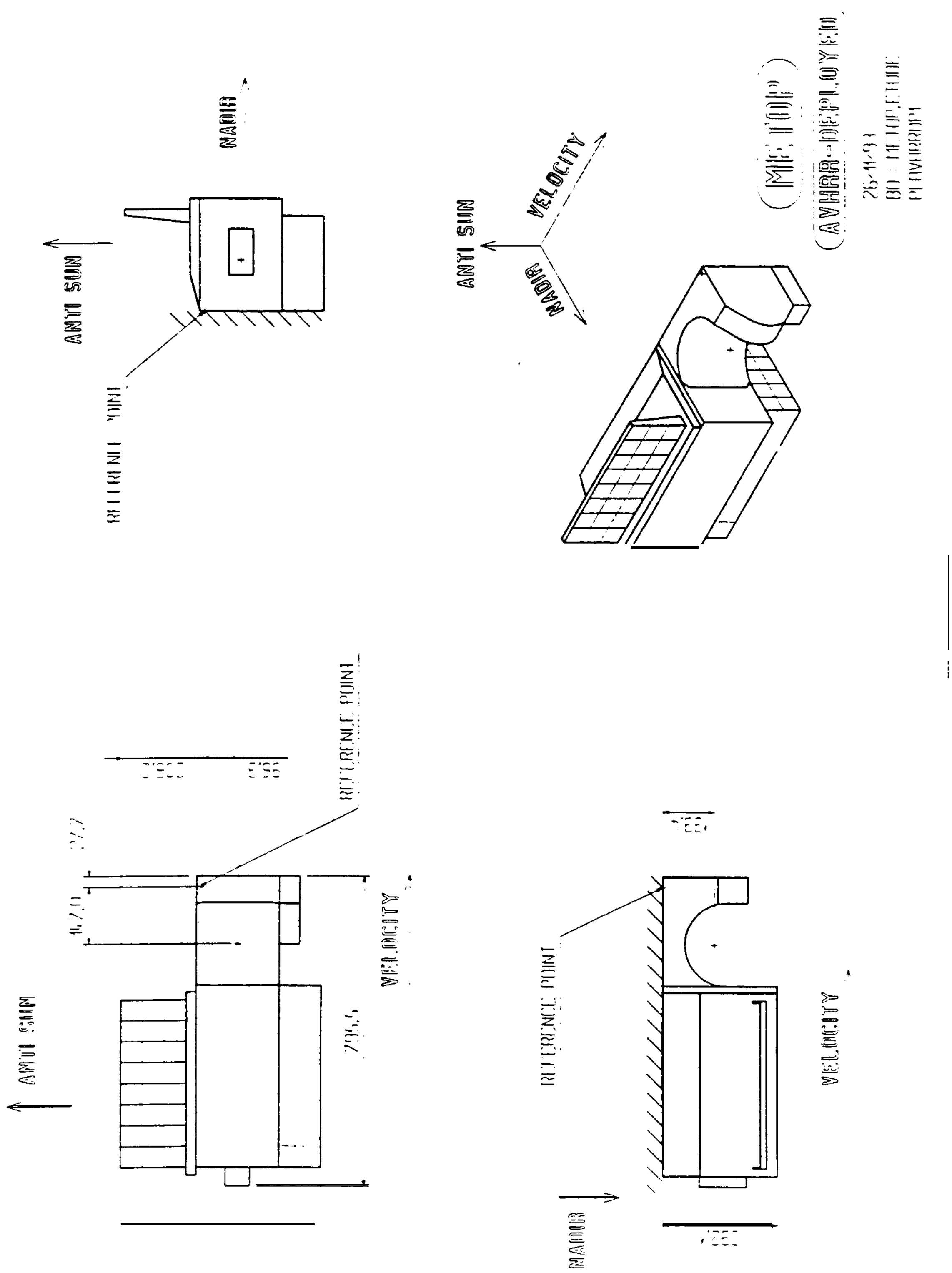


Figure 2. 1/2 : AVHRR/3 Deployed Configuration

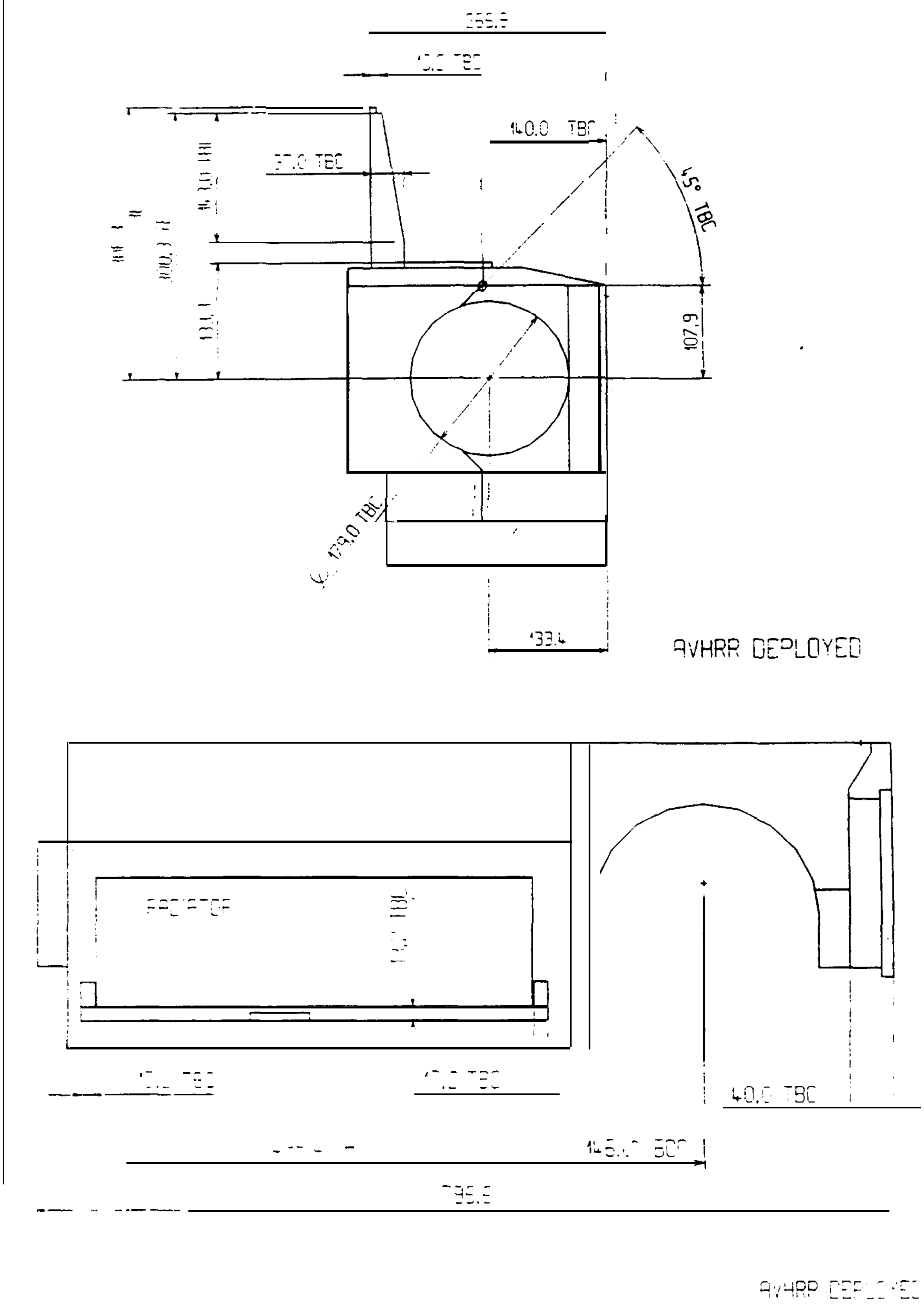


Figure 2.1/3 : AVHRR/3 Dimension Drawing in Deployed Configuration

Moments of Inertia

The AVHRR/3 **moments** of **inertia are as follows. The** coordinate system used is the Instrument Mounting Interface Reference Frame, F_{AVHRR}, with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing). The directions of the F_{AVHRR} axes are the same as the Spacecraft Reference Frame F_S. The accuracy of these values is within T'BD % of the total instrument moment of inertia for each axis.

Module /Unit	Moments of Inertia ($kg.m^2$)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
AVHRR/3 Stowed	TBD	TBD	TBD	TBD	TBD	TBD
AVHRR/3 Deployed	7.904	1.717	7.997	TBD	TBD	TBD

AVHRR/3 Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

Cooler Door Opening : the available data (0.14 Nms / 1.25 in.lb.sec over 0.1 sec) are to be clarified.

Scanning ramp-up (ramp-down) is TBD

2.1.4.2. Continuous and Recurring Transient Events

The AVHRR/3 **scan** motor rotates at a 360 rpm rate. This causes the IFOV to scan scenes from space, through Earth, to Sun. The total uncompensated kinetic momentum of the instrument is :

- 0 on the X axis
- 0.27 Nms (38 in.oz.sec) on the Y axis (scenes are scanned from Space, through Earth, to Sun)
- 0 on the Z axis

The static and dynamic unbalance values on each axis are TBD.

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

2.1.5. Field of View Definition

AVHRR/3 boresight is defined as the nadir direction. The instrument field of view definition is :

- vertex (Cf. drawing)
- Spacecraft provision :
  - cross-track scan plane : from 75 deg. anti-Sun-wards to 58 deg. Sunwards.

    This is the general envelope for 2.5” margin + 55.5” Sunwards + 62.5” anti-Sun-wards + 7.5” anti-Sun calibration + 5” margin
  - Orbit plane : ± 2.5 deg.

AVHRR/3 field of view is illustrated in Figure 2.1.5/1.

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

AVHRR/3 is mounted to the spacecraft balcony using 6 bolts passing through flanges.

The bolt size, length and torque required to mount the instrument are :

Module / Unit	Bolt Size	Length **(mm)**	**Torque (Nm)**	**Quantity**
AVHRR/3				6

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for AVHRR/3 is given in the Mechanical Interface, Control Drawing. TBD (Cf. drawing).

2.2.3. Mounting Surfaces

The mounting surface is on the nadir wall of the platform. The flamess of the mounting surface does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of 645 mm^2 (TBC).

2.2.4. **Materials**

The material of the AVHRR/3 baseplate is aluminium alloy. An alodyne 600 finish is applied to the material at the mounting area The balcony is a 50 mm alummium honeycomb panel with CFRP facing skins (TBC). GFRP stand-offs will be used between the AVHRR/3 mounting feet and the spacecraft balcony.

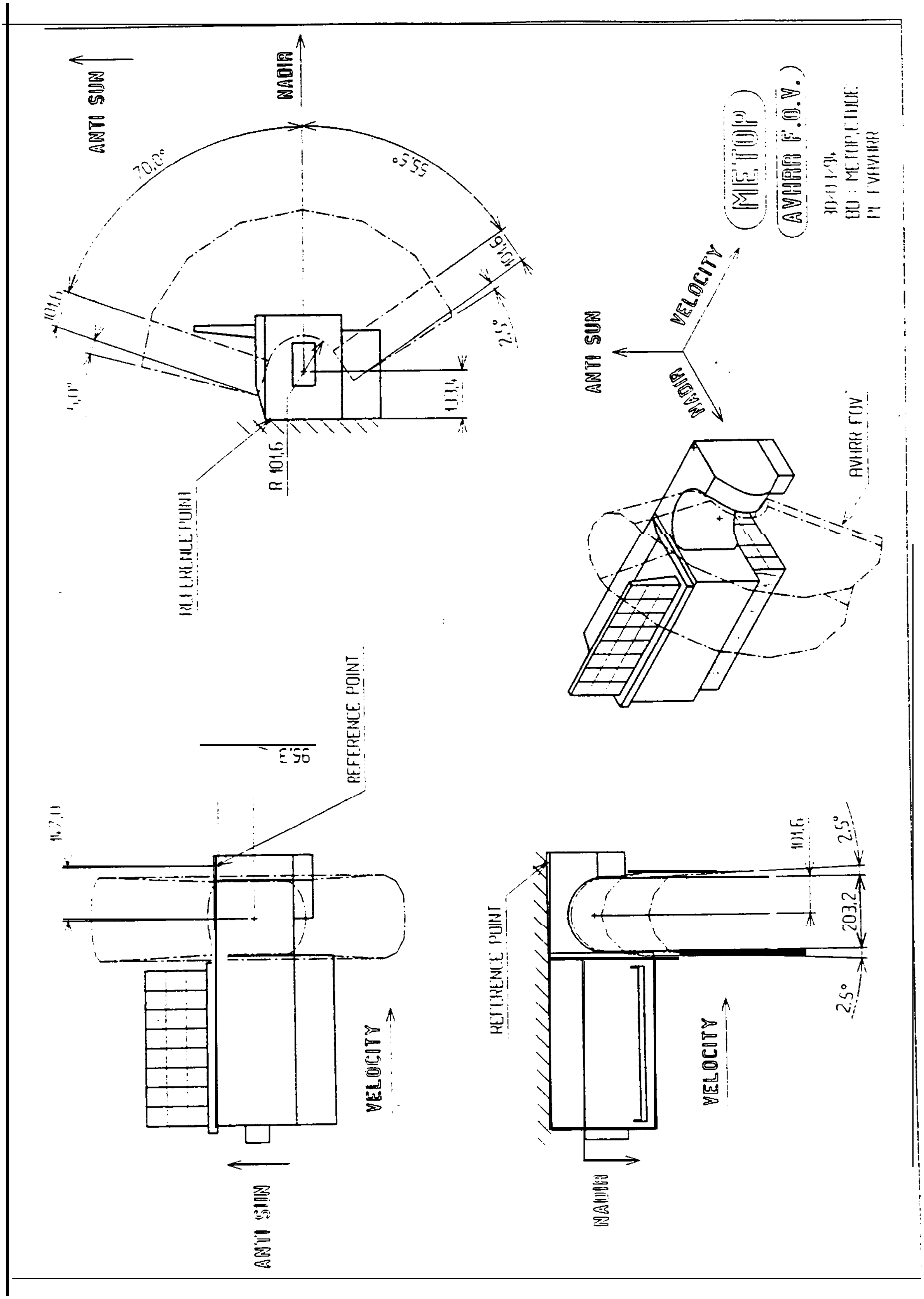


Figure 2.1.5/1 : AVHRR/3 Field of View

2.25 Interface Loads

The calculated interface loads induced by the AVHRR/3 instrument are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
AVHRR/3 Baseplate				

2.2.6. Accessibility

AVHRR/3 connectors are located on the +X (METOP) side of the instrument. Special accessibility is required by the use (TBC) of thermal targets for the whole spacecraft thermal vacuum tests.

2.2.7. Grounding Point

The locations of the grounding points on the AVHRR/3 instrument are defined in TBD.

2.3. POINTING

The pointing requirements for the AVHRR/3 instrument are expressed at the Instrument Mounting Interface Reference Frame F_{AVHRR}

Absolute Pointing Error (Accuracy) : ± 0.15 deg. (3σ)

Absolute Measurement Error (Knowledge) : ± 0.10 deg. (3σ)

Absolute Rate Error (Rate) : ± 0.005 deg./sec. (3σ)

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical Interface Control **Drawing, TBD** (Cf. drawing). The cube has two alignment surfaces of size 145 1.6 mm^2 which are viewed from the spacecraft $+X_s$ and $-Y_s$ axes and meet the requirements specified in the GICD.

The cube shall be covered with a cover in accordance with TBD prior to launch.

2.4.2. Alignment Procedure

2.43. Co-Alignment

There is no requirement for co-alignment for AVHRR/3. Several other instruments have a requirement to be co-aligned with AVHRR/3 HIRS/3, AMSU-Al. AMSU-A2, MHS and IASI

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD.

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequency of the AVHRR/3 instrument is 108 Hz in its stowed configuration, this value having been established by both test and analysis.

As this frequency is above the 100 Hz limit, no mechanical interface model is required.

2.4. MECHANISMS

2.6.1. Functional Description

AVHRR/3 contains two movable mechanisms :

- the hysterisis synchronous motor of the scan mirror rotates at a constant 360 rpm rate. This causes the IFOV to scan scenes from space, through Earth, to Sun.
- a one shot solenoid actuated by a spring driven deployment mechanism, to deploy the top cooler cover.

2.6.2. Performances

The scanning mirror is always running and cannot be parked (synchronization problem). Hence the mechanism shall be ON during Launch and degraded modes.

2.7. PYROS

None

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

2.8.2. Removable Covers (Non-Flight Items)

2.8.3. Deployable Covers (Flight Items)

3. THERMAL INTERFACE DESCRIPTIOK

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

AVHRR/3 is a Category C instrument. Its thermal control is autonomous with dedicated radiators on the instrument side, save for the thermal control of its mounting plane which is controlled by the platform.

The three thermal infra-red detectors are cooled by a two-stage passive radiant cooler. They are mounted on a cold patch that has a 146 cm^2 (22.4 sq. in.) radiating area. This patch cools to 98 K with no control power. During nominal operation its temperature is controlled at 105 K.

3.1.2. Thermal Control Philosophy

Normal Operation

AVHRR/3 dissipates a continuous dissipation of TBD Watts and receives varying environmental heat inputs of between TBD and TBD Watts. TBD Watts is radiated to space from the cryogenic radiators, TBD Watts is radiated from the optical areas (telescope. mirror) of the instrument and the radiator area on the baseplate radiates TBD Watts. On TIROS this radiator size is 210 sq. in., i.e. 0.136 m^2 (about 457 x 305 mm).

Heaters on the baseplate are used to maintain the instrument at a constant temperature. The heater power is controlled by a circuit in the platform thermal control unit (TCU) which is turn controlled by the platform using data from a thermistor on the AVHRR/3 baseplate. The heater power is reduced and increased as the environmental heat inputs change to maintain the baseplate at a constant temperature within ± TBD deg. C in an obit. in an overall range of between 15 and 20 deg. C.

A Sun shield on the balcony is used to prevent solar illumination of the baseplate radiator area and the cryogenic radiator door. It has an interior high infra-red reflectance finish on its interior to reflect radiation from the baseplate radiator to space.

Contingency Modes

During the contingency modes the instrument is switched off. The temperature of AVHRR/3 will be maintained between 10 and 25 deg. C by survival heaters which are controlled using thermostats with a lower set point of 10 deg. C

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating. nonoperating and switch-on temperatures for the AVHRR/3 instrument are defined below The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C AVHRR/3	Operation Min.	Operation Max.	Non-Operation Min.	Non-Operation Max.	Switch-On Min.
Acceptance	+10	+30	0	+30	0
Qualification (TBC)	+5	+30	-5	+30	-5

Stability Requirements

The maximum rate of change in temperatures of the AVHRR/3 instrument measured at the Temperature Reference Point shall be less than 2 deg. C / hour during operation. This requirement is not understood as an instantaneous rate, but as a short term rate : **the maximum** allowable AT measured at the Temperature Reference Point for any time period of 1 hour shall be less than 2 deg. C (TBC).

3.2.2. Radiative interfaces

The focal plane assembly radiator on the $-X_{AVHRR}$ axis of the instrument requires a Gebhart factor of greater than 0.98 (TBC) to space. Surfaces of other instruments may be permitted in the radiator field of view provided that this Gebhart factor requirement is met. In that respect, the identified interactions with HIRS/3 and IASI instruments are acceptable (TBC). This cryogenic radiator operates at a temperature of 105 K.

The baseplate radiator requires a minimum radiation term to space of 4.115×10^{-9} W/K^4 (112.5 sq. in.).

The spacecraft contractor shall ensure that there is no solar illumination of the AVHRR/3 cryogenic radiator door during normal operation.

3.2.3. **Heater** Power Budgets

The heater power budgets for the AVHRR/3 instrument are :

Module /Unit	Heater **Power Budget (Watts)**			
	Operating Hot Case	**Operating Cold Case**	**Off Cold Case**	**Off Safe Mode**
AVHRR/3	**32.0**	**32.0**	**24.9**	**24.9**

These heater powers are provided by the platform for the active thermal control of the AVHRR/3 instrument baseplate

The resistance of the heaters is TBD

3.2.4. Instrument Thermal Dissipation

The dissipation of the AVHRR/3 instrument is constant throughout the orbit and is :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
AVHRR/3	N/A	29.1 (TBC)	29.1 (TBC)	0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform balcony and the AVHRR/3 instrument for different cases are :

Conductive Heat Transfer

Module Nnit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
AVHRR/3	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

Operating Radiative Heat Transfer

Module /Unit	Radiative Heat Transfer (Orbit Average, Watts)	
	Hot Case	Cold Case
AVHRR/3 Baseplate Radiator	TBD	TBD

3.2.6. Thermo-Elastic Interface

The AVHRR/3 instrument has an aluminium baseplate with a coefficient of thermal expansion of 25 x 10^{-6} / deg C (TBC). The interfacing structure for the AVHRR/3 instrument is aluminium honeycomb with CFRP skins, with a coefficient of thermal expansion of 2.0 x 10^{-6} / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD

3.3.2. Conductive Interfaces

The conductive interfaces are the 6 mounting feet which are defined in the Mechanical Interface Control Drawing (TBD), and in § 2.2.3. GFRP stand-offs will be used between the AVHRR/3 mounting feet and the spacecraft balcony.

The total thermal conductance between the AVHRR/3 instrument and the balcony is TBD W/K

The calculated temperatures at the AVHRR/3 conductive interfaces are TBD.

3.3.3. Radiative Interfaces

The external surfaces of the AVHRR/3 instrument. and the finishes used are given in the Thermal interface Drawing (TBD). The main finishes are given in Figure 3.3/1 The baseplate radiator is not a flat planar surface (TBC). The area of the baseplate used as a radiator is given in Figure 3.3/2.

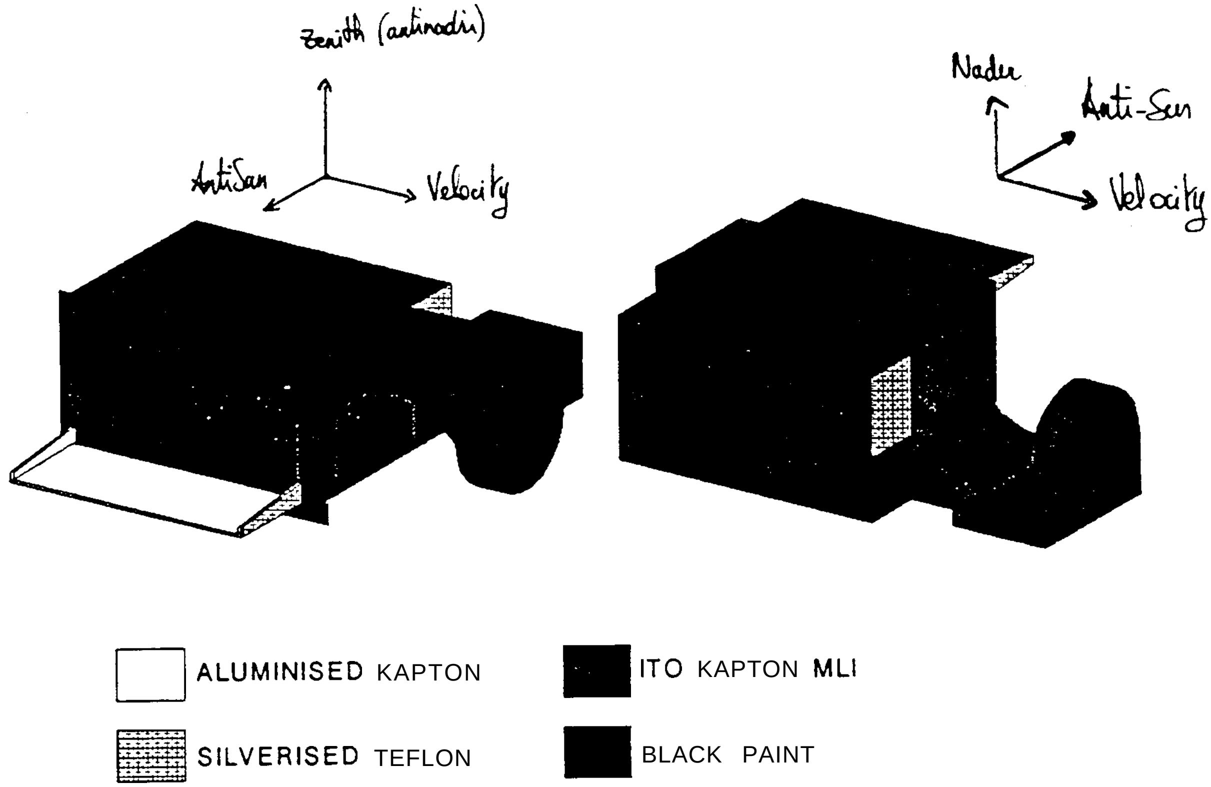


Figure 3.3/1 : AVHRR/3 Thermal Finishes

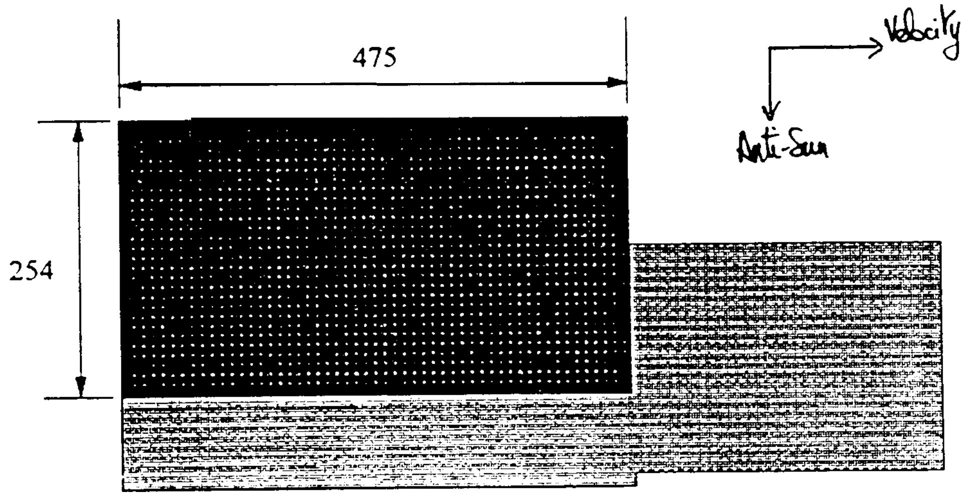


Figure 3.3/2 : AVHRR/3 Baseplate Radiator Area

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red Emittance
	BOL	EOL	
Silver Teflon	0.09	TBD	0.76
Black Paint	0.96	TBD	0.91
GOLD	0.33	TBD	0.03
VDA (vacuum deposited ahuninium)	0.06	TBD	0.035
Aluminium Tape	0.25	TBD	0.04
Kapton (MLI ext.)	0.35	TBD	0.53
White Paint	0.22	TBD	0.90
Black Honeycomb (cal. targets)	0.98	TBD	0.99

AVHRR/3 Material Thermo-Optical Properties (TBC)

The radiative environmental temperatures for AVHRR/3 are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacity of AVHRR/3 is TBD J/K.

3.3.5. Instrument Temperature Measurement

2 thermistors. Location : TBD.

3.3.6. Thermal Mathematical Models

AVHRR/3 reduced modelling in SINDA/TRASYS is under progress and should be completed by January 1995.

3.4. THERMAL ENVIRONMENT CONDITIONS

Nominal Operations (Earth Pointing)

Assuming that the motor is still running, AVHRR/3 has no problem with viewing the Sun from its optical aperture (a bad position of the mirror is then avoided).

Assuming a 105 K starting temperature. AVHRR/3 coolers and detectors can survive a 14 minute direct Sun exposure.

The platform guarantees that there is no direct Sun illumination of the mounting plane radiator

Direct illumination of the top radiator and of the back of the Earth cover shall be avoided.

Safe Mode Operations (Sun Pointing)

The platform guarantees that there is no direct Sun illumination of the mountmg plane radiator.

The behaviour of the top radiator in safe mode (instrument OFF. scanning motor running) is TBD

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Power Sources

AVHRR/3 requires to be power supplied with the following buses :

Power Bus	Number of Interfaces	Goals	TIROS Name
+ 28 V regulated power bus	2	One for the instrument primary power One for the scanning mechanism	Main regulated bus # 1 Main regulated bus #2
+ 10 V regulated power bus	1	One for commands and digital B command verification telemetry	Interface Bus

In addition, a connection with a heater power for the instrument baseplate shall be foreseen :

+ 28 V regulated heater power bus	1	One for the active thermal control (instrument baseplate)

Normal operation of the instrument is guaranteed if the voltage remains in the range 27 V - 29.5 V.

Note that the power connection is not redunded on the instrument side (TBC).

Power Consumption and Modes

Basic Power Consumption	LEOP	Instr. ON	PLM Fix	PLM Safe	Decontamination	Commissionning
+ **28 V** regulated power bus :						
Primary power	Off	18.3 W	off	Off	21.2 W	6W
Scanning mechanism	8.1 W	8.1 W	8.1 W	8.1 W	8.1 W	8.1 W
+ 10 V regulated power bus	OffTBC	TBD W	OffTBC	OffTBC	TBD W	TBD W
TOTAL	**8.1 w**	**26.4 W**	**8.1 W**	**8.1 W**	**29.3 W**	**14.1 w**

The active thermal control shall be included in the platform budget. The need is :

+ 28 V regulated power bus	Off TBC	32.0 W (TBC)	24.9 W (TBC)	24.9 W (TBC)	TBD	TBD

Note that the radiant cooler cover deployment requires 56.9 W This occurs only once for a period of approximately 1 sec. (acquisition phase).

4.2. COMMAND AND CONTROL INTERFACES

AVHRR/3 synchronously operates with reference to a 998.4 kHz clock. For operation of the scanner motor during launch, the accuracy of this clock is not high : TBD.

30 pulse discrete commands (no level discrete command).

The duration of the pulse commands can be standardized at 60 ms.

4.3 SCIENCE DATA INTERFACES

Two science data flows are taken out of AVHRR/3 : a high resolution HR stream and a low resolution LR stream.

AVHRR/3 is a radiometer with 6 channels but only 5 channels are operated at a time. Each of them parallelly delivers 10-bit word to the platform_ and the resulting 50 bits are named a sample.

Within one scan (i.e. 1/6 = 166.67 ms), AVHRR/3 delivers 271 samples of measurement data. The apparent data rate is then 62 1.300 kbps.

These 103 550 bit data are encapsulated into one source packet of 12 944 octets and the resulting source packet total length is 12 958 octets. The packetized data rate is then 621.984 kbps (high rate).

For the low rate format, three out of five channels are selected and a 10: 1 compression rate is applied (TBC). The apparent data rate after compression is 37.278 kbps.

The 6213 bit data are encapsulated into one source packet of 777 octets and the resulting source packet total length is 79 1 octets. The packetized data rate is then 37.968 kbps (low rate).

4.4. HOUSEKEEPING TELEMETRY

Analog housekeeping telemetry :	22	(3 during launch)
Digital housekeeping telemetry (digital B) :	15	
Active thermal control thermo-couple :	1	

Housekeeping acquisition is done in a 3.2 sec. cycle on TIROS. This could be extended to e.g. 16 sec.

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors **Used at Spacecraft Interfaces**

4.52. **Connectors Used for inter-Instrument Unit Interface**

4.5.3. **EMC Aspects**

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCFUPTION

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

Contamination witness mirror : TBD.

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.3.1. Quasi-Static Test

7.2.3.2. Dynamic Model Validation

N/A (AVHRR/3 first natural frequency is above 100 Hz).

7.2.3.3. Vibration Tests

AVHRR/3 is the result of an evolution of instruments AVHRR/2 was qualified to levels much higher that the values used for AVHRR/3. Two alternatives are possible :

- AVHRR/3 could claim that the qualification levels of AVHRR/2 cover AVHRR/3. In this case AVHRR/3 for METOP will need only acceptance testing according to the METOP GICD rules.
- AVHRR/3 is different to AVHRR/2 and cannot claim previous qualification. In this case AVHRR/3 will need qualification testing as defined in METOP GICD.

If the path of only acceptance by METOP is chosen, it will be necessary to provide documentation that proves that the differences between AVHRR/2 and /3 are small enough to justify this approach. It will be necessary to provide documentation detailing the mechanical qualification of the AVHRR/2.

We propose to indicate the resulting test programmes for AVHRR/3 that will result in both cases.

Sinus or Burst

Note : AVHRR/3 first natural frequency is 108 Hz

Status on NOAA Levels

AVHRR/2 was sinus qualified to 11.5 g thrust axis and 7.5 g in both lateral axes.

For AVHRR/3, and according to NOAA documentation. sinus test is not necessary, but a qualification bursr test shall be conducted by applying 15.55 g for the AVHRR/3 in the three axes. An acceptance burst test shall be conducted by applying 12 4 g for the AVHRR/3 in the three axes

METOP Required Levels

The sinus level test of AVHRR/2 does not wver the sinus profile requested in the METOP GICD (15 g in the three axes) ; then the AVHRR/2 sinus test cannot be claimed as qualification for METOP. However the level of the burst test requested by NOAA for AVHRR/3 is larger than 15 g.

Note the discrepancy in the duration : 0.5 s for NOAA versus the 1 s. requested by METOP GICD. The NOAA test frequency shall be clarified.

Random Vibrations

Status on NOAA Levels

AVHRR/2 was qualified with a constant level of 0.085 g rms from 20 to 2000 Hz. This produces a total of 12.9 g rms.

As per NOAA documentation, for AVHRR/3, the qualification levels are the following :

Frequency (Hz)	20 to 60	60 to 1000	1000 to 2000
Power Density	+8 dB/Oct	0.04 g^2/Hz	-3 dB/Oct.

Total 8.12 g rms. Duration 1 min/axis

The acceptance levels are identical to qualification levels.

METOP Required Levels

The application of the METOP GICD levels produces for an AVHRR/3 of 3 1 kg the following levels :

Qualification Levels

Frequency (Hz)	20 to 100	100 to 400	400 to 2000
Power Density	+3 dB/Oct	0.079 g^2/Hz	-3 dB/Oct.

The conclusion is that the Qualification Levels required by METOP for AVHRR/3 are below the Qualification Levels of AVHRR/2. If AVHRR/3 can claim that it has been qualified — through AVHRR/2 — to levels more stringent than METOP ones, it will need only acceptance testing. The METOP *required* levels are then :

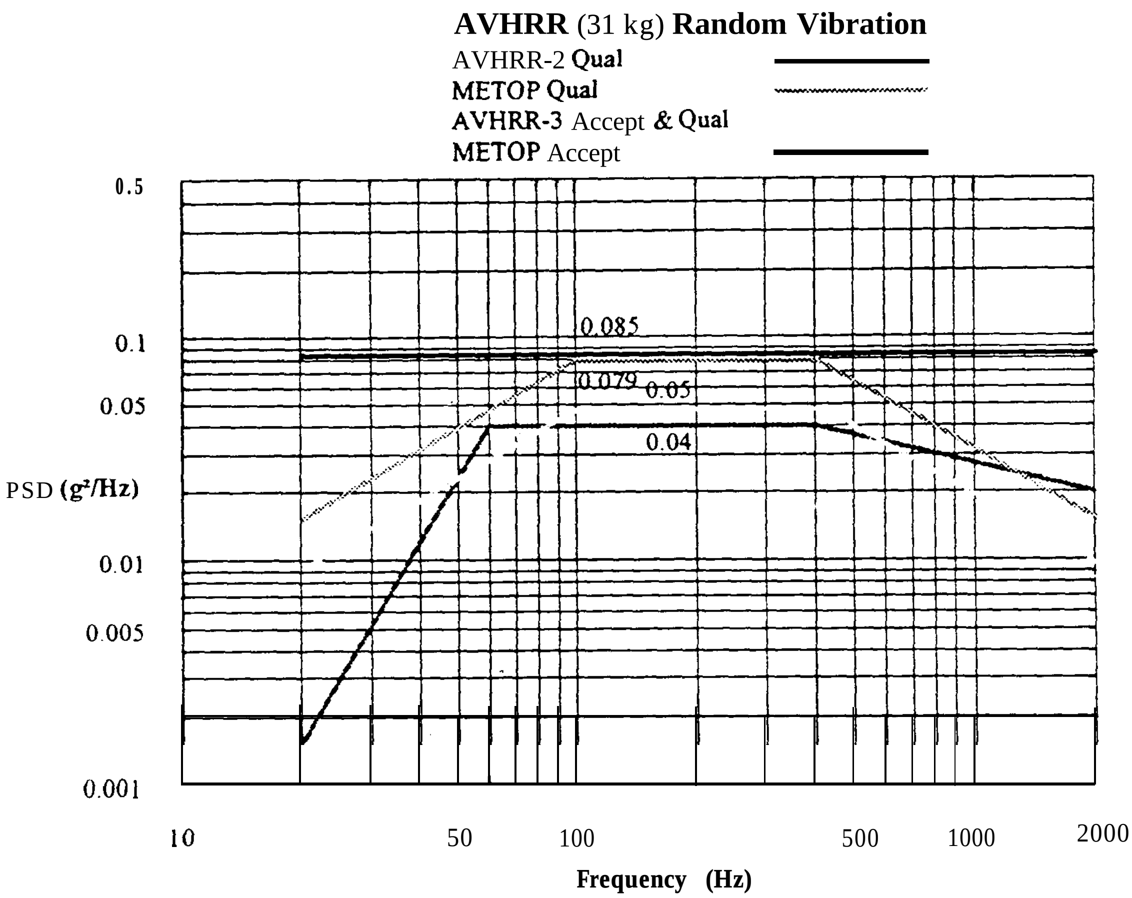
Acceptance Levels

Frequency (Hz)	20 to 100	100 to 400	400 to 2000
Power Density	+3 dB/Oct	0.0505 g^2/Hz	-3 dB/Oct.

These levels are above AVHRR/3 NOAA specified qualification levels ; so — if previous qualification is claimed — AVHRR/3 for METOP should increase the levels to the Acceptance Levels of the previous table.

If AVHRR/3 does not claim coverage by AVHRR/2 levels. then the above mentioned METOP qualification levels apply.

Levels can be seen in the graphic below:



For simplification the graphs only include the levels for the perpendicular directions **nor the lateral ones.**

7.2.3.4. Acoustic Test

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

For testing at spacecraft level, AVHRR/3 will provide one Portable Test Unit (PTU) and two thermal vacuum targets (simulating space and Earth viewing) and their respective controllers. This equipment will operate at both 110 and 220 VAC, 50-60 Hz.

The possibility to have semi-automated test sequences with the PTU (or equivalent) is under evaluation.

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

None.

9.1.2. Instrument Engineering Model (EM)

None.

9.1.3. Instrument Proto-Flight Model (PFM)

None.

9.1.4. Instrument Flight Model (FM)

2 Flight Models are to be delivered for METOP.

9.15 Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

The contamination witness mirror shall be removed prior to vibration testing and launch

The alignment cubes shall be removed before launch.

On TIROS platform, an end-to-end testing at system level is performed in the thermal vacuum chamber. For AVHRR/3, stimuli are required for cryogenic cooling and to simulate deep space and Earth scene conditions. The applicability to the METOP satellite is TBD. Note that only the infra-red channels require these stimuli, as the visible channels are optically simulated at ambient conditions.

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

AVHRR/3 **shall be** powered on during the launch phase (Cf. § 4.1).

Telemetry shall be acquired from AVHRR/3 **prior to** launch **for** health status (rationale TBD), and after launch (Cf. § 4.4) but direct down-link with the ground is not required.

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

AVHRR/3 **is** continuously on along the orbit **(duty cycle** 100%).

Commissioning and calibration : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.42. Observability

10.4.3. Information Provided by the Platform

Once **switched on,** AVHRR/3 **nominally** proceeds without any requirement for software or parameters update but the channel selection.

Automatic Channel Selection

The instrument requires a day/night mode switching from the platform, in order to use the channel **3A during the** day (cloud clearing purpose) and the channel 3B at night (for cloud / surface temperature measurement purpose). **Because** of the swath, it does not really matter whether this signal generated twice per orbit occurs at the day/night terminator of the spacecraft or at the sub-satellite point.

10.5. INSTRUMENT OPERATION MANUAL

The initial decontamination period lasts two weeks Subsequent decontamination is approximately equal to one week duration.

AVHRR/3 requires to go regularly (every TBD months) into this decontamination mode.

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime :	3 years
Reliability :	Not specified
Flight Experience :	more than 5 years

12. PROGRAMME AND SCHEDULE

AVHRR/3 is scheduled for a first flight on NOAA-K in 1995.

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

HIRS/3

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the HIRS/3 Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with HIRS/3 responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

The High Resolution Infra-Red Sounder HIRS/3, scans the Earth surface in twenty spectral bands in the range of 0.69 - 14.95 microns. It provides data for temperature - altitude profiles, moisture content, cloud height and surface albedo.

HIRS/3 has an instant foot print in nadir of 20 km. Scanning is cross-track with a total field of view of ± 49.5 deg. about nadir. The instrument uses an internal step scan mirror which scans in 1.8 deg. increments at a set rate of 10 steps per second (the mirror steps in less than 35 msec, then holds at each position while the 20 filter segments are sampled).

The short-wave and long-wave infra-red detectors are mounted on a passive radiator and operate at a stabilized 100 K temperature. An Earth shield on the cooler door assembly insulates the door from Earth direction thermal input. The door is released after the initial orbital outgas period. If there are indications of subsequently contaminate accumulation, a door-open outgas procedure can be performed by applying power to the heaters located on both stages of the radiant cooler. During this procedure, the cooler temperature rises to approximately 300 K.

The instrument sensitivity (noise equivalent spectral radiance, NEANT, in mW/ (m2 ST cm-l)) are illustrated in Table 1.2/1.

Scan Type : Step Starer
Scan Rate(s) : 6.4
IFOV (deg.) : 0.69 (circular)
Sampling Interval (deg.) : 1.8
Earth View Pixels per Scan : 56
Swath (deg. with respect to the nadir direction) : ± 49.5 deg
Synchronization with AMSU A (8 s repeat time) : TBD.

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ret MMS/MET/SPE/JLD/159.94. Iss. 2. dated Sept. 94

Reference Documentation

Unique Interface Specification for HIRS/2 (applicable to HIRS/3)
Ref IS-2285780 (MET0029). dated October 1991. Rev G

Performance Specification for the NOAA-N, N' and METOP-1 HIRS/3
Ref. S-480-28.2 (MET0153), dated March 1993, Rev. C

Performance Assurance Requirements for the NOAA-K, L & M AVHRR/3 and HIRS/3
Ref. S-480-29.1 (MET0154), dated March 1990, Rev. G

Outline Drawing HIRS/2I and HIRS/3 Instruments
Ref. 8 129882 (MET0506), dated March 1993, Rev. C

HIRS/3 Thermal Interface Drawing
Ref. 8 129935 (MET0505), dated March 1993, Rev. A

Channel	Wavelength (pm)	Sensitivity (NEΔNT)
1	14.95	3.00
2	14.71	0.67
3	14.49	0.50
4	14.22	0.31
5	13.97	0.21
6	13.64	0.24
7	13.35	0.20
8	1111	0.10
9	9.71	0.15
10	12.47	0.15
11	7.33	0.20
12	6.52	0.20
13	4.57	0.006
14	4.52	0.003
15	4.41	0.004
16	4.45	0.004
17	4.13	0.002
18	4.00	0.002
19	3.76	0.001
20	0.69	0.10% albedo

Figure 1.2/1 : HIRS/3 Channel Allocation and Sensitivity

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

HIRS/3 consists of a single unit. The Part Number and Identification Code of the HIRS/3 instrument are :

PART NO : T B D

ID CODE : TBD

The location of the labels giving these Part Numbers and Identification Codes are defined in the Mechanical Interface Control Drawing.

The stowed envelope is : L (Velocity) x W x H (Earth) 677 x 469 x 406 mm.

The in-orbit configuration is reached as soon as the top radiator cover is open.
The deployed configuration is then : L (Velocity) x W x H (Earth) 677 x 629 x 406 mm

2.1.2. Mechanical Interface Control Drawing

The HIRS/3 instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The HIRS/3 stowed and deployed configurations are illustrated in Figures 2.1/1 and 2.1/2

2.1.3. Mass Properties

Mass

The mass properties of the HIRS/3 instrument are given in the following table. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{HIRS} , *with the origin* being at the reference mounting hole location as defined in the Mechanical interface Control Drawing, TBD (Cf. drawing). The directions of the F_{HIRS} axes are the same as the Spacecraft Reference Frame F_S. The HIRS/3 centre of gravity location in the deployed configuration has been measured.

Module /Unit	**Basic Mass (± TBD kg)**	**Centre of Mass Location (± 5 mm)**		
		X_{HIRS} (Sun)	Y_{HIRS} (Anti-velocity)	Z_{HIRS} (Zenith)
HIRS/3 Stowed	33.1 kg **(73** lb)	+ 1359mm	+ 321.4 nun	-141.5 mm
HIRS/3 Deployed	33.1 kg (73 lb)	+ 134.9 mm (5.31 in)	+ 310.9 mm (12.24 in)	-143.5 mm (5.65 in)

HIRS/3 Mass Properties

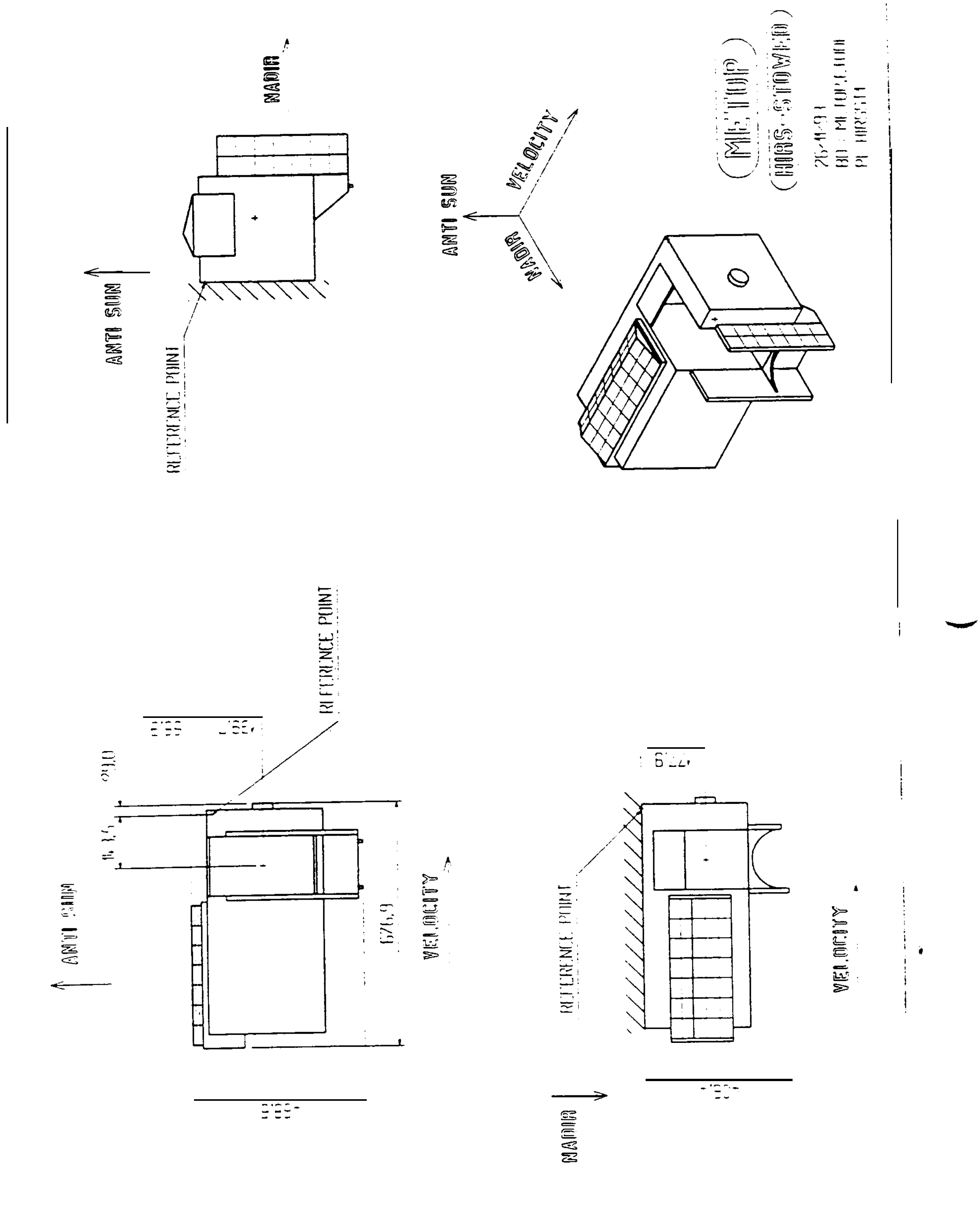


Figure 2.1/1 : HIRS/3 Stowed Configuration

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

HIRS/3 consists of a single unit. The Part Number and Identification Code of the HIRS/3 instrument are :

PART NO : TBD

ID CODE : TBD

The location of the labels giving these Part Numbers and Identification Codes are defined in the Mechanical Interface Control Drawing.

The stowed envelope is : L (Velocity) x W x H (Earth) 677 x 469 x 406 mm.

The in-orbit configuration is reached as soon as the top radiator cover is open.
The deployed configuration is then : L (Velocity) x W x H (Earth) 677 x 629 x 406 mm

2.1.2. Mechanical Interface Control Drawing

The HIRS/3 instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD

The HIRS/3 stowed and deployed configurations are illustrated in Figures 2.1/1 and 2.1/2

2.1.3. Mass Properties

Mass

The mass properties of the HIRS/3 instrument are given in the following table. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{HIRS} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing). The directions of the F_{HIRS} axes are the same as the Spacecraft Reference Frame F_S. The HIRS/3 centre of gravity location in the deployed configuration has been measured.

Module /Unit	Basic Mass (± TBD kg)	Centre of Mass Location (± 5 mm)		
		X_{HIRS} (Sun)	Y_{HIRS} (Anti-velocity)	Z_{HIRS} (Zenith)
HIRS/3 Stowed	33.1 kg (73 lb)	+ 135.9 mm	+ 321.4 mm	-141.5 mm
HIRS/3 Deployed	33.1 kg (73 lb)	+ 134.9 mm (5.31 in)	+ 310.9 mm (12.24 in)	-143.5 mm (5.65 in)

HIRS/3 Mass Properties

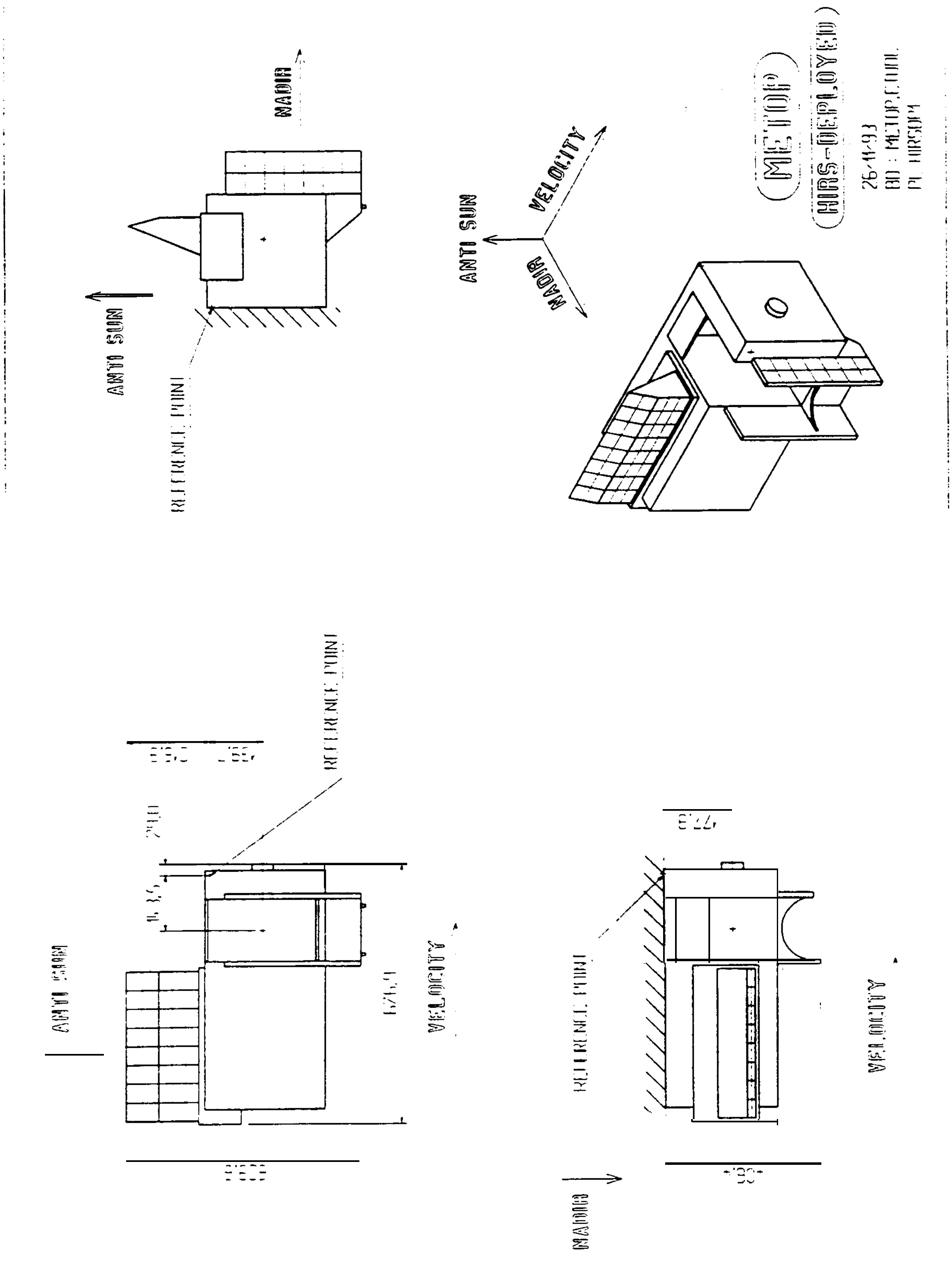


Figure 2. 1/2 : HIRS/3 Deployed Configuration

Moments of Inertia

The HIRS/3 moments of inertia are as follows. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{HIRS}, with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, **TBD (Cf. drawing). The directions of the F_{HIRS} axes are the same as the Spacecraft Reference Frame F_S. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis**

Module /Unit	Moments of Inertia (kg.m^2)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
HIRS/3 stowed	TBD	TBD	TBD	TBD	TBD	TBD
HIRS/3 Deployed	5.522	1.867	5.487	TBD	TBD	TBD

HIRS/3 Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

Cooler Door Opening : TBD
Filter Chopper Drive Ramp-Up : TBD

2.1.4.2. Continuous and Recurring Transient Events

HIRS/3 step scanning (scenes are scanned from Sun, through Earth, to space) is uncompensated. The total uncompensated kinetic momentum is :

- 0.220 Nms (2 in.lb.sec) on the X axis
- 0.007 Nms (1 in.oz.sec) on the Y axis
- 0.007 Nms (1 in.oz.sec) on the Z axis

The scan axis torque and the static and dynamic unbalance values on each axis are TBD

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

2.1.5. Field of View Definition

HIRS/3 boresight is defined as the nadir direction. The instrument field of view definition is

- vertex : Cf. drawing
- Spacecraft provision :
  - cross-track scan plane : from 73 deg. anti-Sun-wards to 5 1 deg. Sunwards.

This is the general envelope for 1.5° margin + 49.5" Sunwards + 49.5° anti-Sun-wards + 2 1.6' anti-Sun calibration + *1.5"* margin

- Orbit plane : ± 2.0 deg.

HIRS/3 field of view is illustrated in Figure 2.1.5/1.

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The HIRS/3 instrument is mounted to the spacecraft balcony using six mounting feet.

The bolt size, **length** and torque **required to** mount the instrument are:

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
HIRS/3				**6**

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for HIRS/3 is given in the **Mechanical Interface** Control Drawing, TBD (Cf. drawing,).

2.2.3. Mounting Surfaces

The mounting surface is on the nadir wall of the platform. The flatness of the mounting surface does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of 645 mm^2 (TBC).

2.2.4. Materials

The material of the HIRS/3 baseplate is aluminium alloy. An alodyne 600 finish is applied to the material at the mounting area. The balcony is a 50 mm aluminium honeycomb panel with CFRP facing skins (TBC). GFRP stand-offs will be used between the HIRS/3 mounting feet and the spacecraft balcony.

2.2.5. **Interface Loads**

The calculated interface loads induced by the HIRS/3 instrument are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
HIRS/3 Baseplate				

2.2.6. Accessibility

HIRS/3 connectors are located on the +X (METOP) side of the instrument. Special accessibility is required by the use of thermal targets for the *whole* spacecraft thermal *vacuum tests* (TBC).

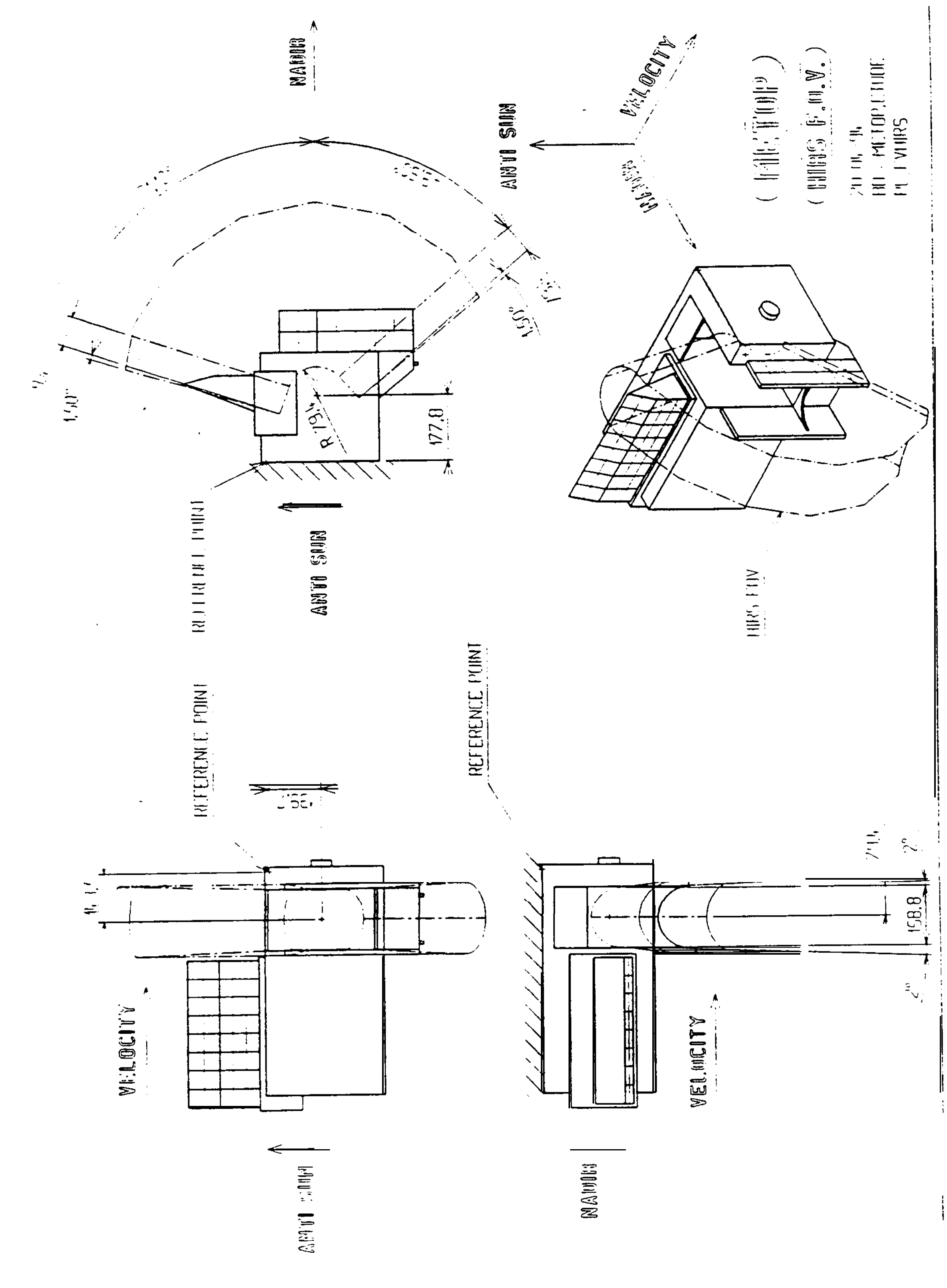


Figure 2.1.5/1 : HIRS/3 Field of View

This is the general envelope for 1.5° margin + 49.5” Sunwards + 49.5’ anti-Sun-wards + 21.6” anti-sun calibration + 1.5” margin

- Orbit **plane** : **± 2.0** deg

HIRS/3 field of view is illustrated in Figure 2.1.5/1.

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The HIRS/3 instrument is mounted to the spacecraft balcony using six mounting feet.

The bolt size, length and torque required to mount the instrument are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
HIRS/3				6

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for HIRS/3 is given in the Mechanical Interface Control Drawing. TBD (Cf. drawing).

2.2.3. Mounting Surfaces

The mounting surface is on the nadir wall of the platform. The flatness of the mounting surface does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of 645 mm^2 (TBC).

2.2.4. Materials

The material of the HIRS/3 baseplate is aluminium alloy. An alodyne 600 finish is applied to the material at the mounting area. The balcony is a 50 mm aluminium honeycomb panel with CFRP facing skins (TBC). GFRP stand-offs will be used between the HIRS/3 mounting feet and the spacecraft balcony.

2.2.5. **Interface Loads**

The calculated interface loads induced by the HIRS/3 instrument are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
HIRS/3 Baseplate				

2.2.6. **Accessibility**

HIRS/3 connectors are located on the +X (METOP) side of the instrument. Special accessibility is required by the use of thermal targets for the whole spacecraft thermal vacuum tests (TBC).

2.2.7. Grounding Point

The locations of the grounding points on the HIRS/3 instrument are defined in TBD

2.3. POINTING

The pointing requirements for the HIRS/3 instrument are expressed at the Instrument Mounting Interface Reference Frame F_{HIRS}

Absolute Pointing Error (Accuracy) :	± 0.15 deg. (3a)
Absolute Measurement Error (Knowledge) :	± 0.10 deg. (3σ)
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical Interface Control Drawing, TBD. The cube has two alignment surfaces of size 145 1.6 mm^2 which are viewed from the spacecraft +Xs and -Ys axes and meet the requirements specified in the GICD.

The cube shall be covered with a cover in accordance with TBD prior to launch.

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

The co-alignment requirements are expressed behveen the lnstrument Mounting Interface Reference Frames (F_{MI}) of each instrument

HIRS/3 shall be co-aligned with AVHRR/3 to within ± 0.05 deg. (3a).

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequency of the HIRS/3 instrument is 188 Hz in its stowed configuration, this value having been established by both test and analysis.

As this frequency is above the 100 Hz limit, no mechanical interface model is required.

2.6. MECHANISMS

2.6.1. Functional Description

HIRS/3 has three mechanisms

- scan mirror drive : 1.8 deg. stepper motor, 0.1 s. step increment
- chopper / filter wheel : hysteresis synchronous motor at 600 rpm
- door : spring loaded hinges with a redundant solenoid actuated cam. It is a release only mechanism.

2.6.2. Performances

2.7. PYROS

None.

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

2.8.2. Removable Covers (Non-Flight Items)

2.8.3. Deployable Covers (Flight Items)

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

HIRS/3 is a Category C instrument. Its thermal control is autonomous with dedicated radiators on the instrument side, save for the thermal control of its mounting plane which is controlled by the platform.

3.1.2. Thermal Control Philosophy

Normal Operation

HIRS/3 **dissipates** a continuous dissipation of TBD Watts and receives varying environmental heat inputs of between TBD and TBD Watts. TBD Watts is radiated to space from the cryogenic radiators, TBD Watts is radiated from the optical areas (telescope, mirror) of the instrument and the radiator area on the baseplate radiates TBD Watts. On TIROS this radiator size is **127 sq. in.,** i.e. **0.82 m^2** (about **266 x 308 mm).**

Heaters on the baseplate are used to maintain the instrument at a constant temperature. The heater power is controlled by a circuit in the platform thermal control unit (TCU) which is turn controlled by the platform using data from a thermistor on the HIRS/3 baseplate. The heater power is reduced and increased as the environmental heat inputs change to maintain the baseplate al a constant temperature within ± TBD deg. C in an obit, in an overall range of between 15 and 20 deg. C.

A Sun shield on the **balcony** is used to prevent solar illumination of the baseplate radiator area and the cryogenic radiator door It has an interior high infra-red reflectance finish on its interior to reflect radiation from the baseplate radiator to space. Some additional shielding is provided on the PLM to prevent solar illumination of the HIRS/3 **door** (TBC).

Contingency Modes

During the contingency modes the instrument is switched off. The temperature of HIRS/3 will be maintained between 10 and 25 deg. C by survival heaters which are controlled using thermostats with a lower set point of 10 deg. C.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the HIRS/3 instrument are defined below. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C HIRS/3	Operation Min.	Operation Max.	Non-Operation Min.	Non-Operation Max.	Switch-On Min.
Acceptance	+5	+25	-10	+30	-10
Qualification (TBC)	0	+30	-15	+30	-15

CAUTION : The HgCDTE long-wave detector is subject to deterioration at *temperatures* above 30 deg. C.

Stability Requirements

The maximum rate of change in temperatures of HIRS/3 instrument measured at the Temperature Reference Point shall be less than 5 deg. C / hour during operation. This requirement is not understood as an instantaneous rate, but as a short term rate : the maximum **allowable AT measured at the Temperature Reference** Point for any time period of 1 hour shall be less than 5 deg. C (TBC).

3.2.2. Radiative Interfaces

The focal plane assembly radiator on the -X_{HIRS} axis of the instrument requires a Gebhart factor of greater than **0.97 (TBC) to** space. Surfaces of other instruments may be permitted in the radiator field of view provided that this Gebhatt factor requirement is met. In that respect, the identified interaction with the IASI instrument is acceptable (TBC). This cryogenic radiator operates at a temperature of 100 K.

The baseplate radiator requires a minimum radiation term to space of 1 .92x10^{-9} W/K^4 (52.5 sq. in.).

The spacecraft contractor shall ensure that there is no solar illumination of the HIRS/3 cryogenic radiator door during normal operation.

3.2.3. Heater Power Budgets

The heater power budgets for the HIRS/3 instrument are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
HIRS/3	15.0	15.0	TBD	TBD

These heater powers are provided by the platform for the thermal control of the HIRS/3 instrument baseplate.

The resistance of the heaters is TBD

3.2.4. Instrument Thermal Dissipation

The dissipation of the HIRS/3 instrument is constant throughout the orbit and is :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency I Safe Mode
HIRS/3	N/A	25.1 (TBC)	25.1 (TBC)	0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the balcony and the HIRS/3 instrument for different cases are :

Conductive **Heat Transfer**

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
HIRS/3	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

Operating Radiative Heat Transfer

Module /Unit	Radiative Heat Transfer (Orbit Average, Watts)	
	Hot Case	Cold Case
HIRS/3 **Baseplate** Radiator	TBD	TBD

3.2.6. Thermo-Elastic Interface

The HIRS/3 instrument has an aluminium baseplate with a coefficient of thermal expansion of **25 x** 10^{-6} / deg. C (TBC). The interfacing structure for the HIRS/3 instrument is aluminium honeycomb with CFRP skins, with a coefficient of thermal expansion of 2.0 x 10" / deg. C. (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD

3.3.2. Conductive Interfaces

The conductive interfaces are the 6 mounting feet which are defined in the Mechanical Interface Control Drawing (TBD), and in § 2.2.3. GFRP stand-offs will be used between the HIRS/3 mounting feet and the spacecraft balcony.

The total thermal conductance between the HIRS/3 instrument and the balcony is TBD W/K.

The calculated temperatures at the HIRS/3 conductive interfaces are TBD.

3.3.3. Radiative Interfaces

The external surfaces of the HIRS/3 instrument, and the finishes used are given in the Thermal Interface Drawing (TBD). The HIRS/3 thermal coatings are illustrated in Figure 3.3/1. The baseplate radiator is not a flar planar surface (TBC) The area of the baseplate used as a radiator is given in Figure 3.3/2.

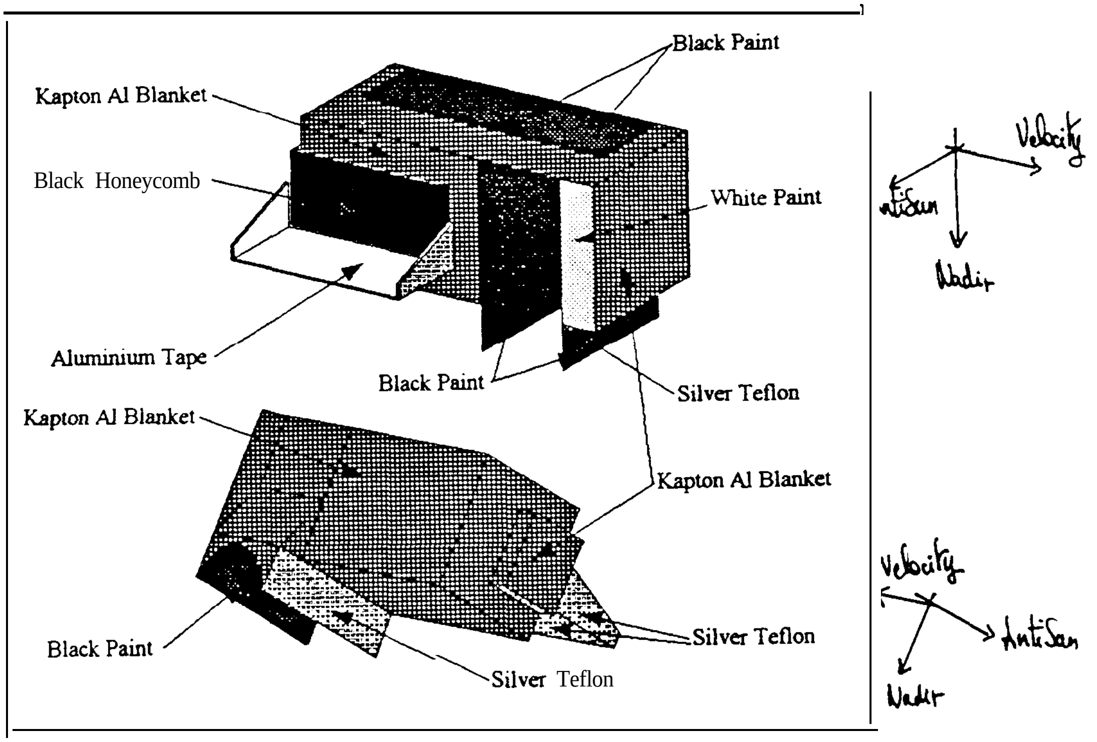


Figure 3.3/1 : HIRS/3 Thermal Finishes

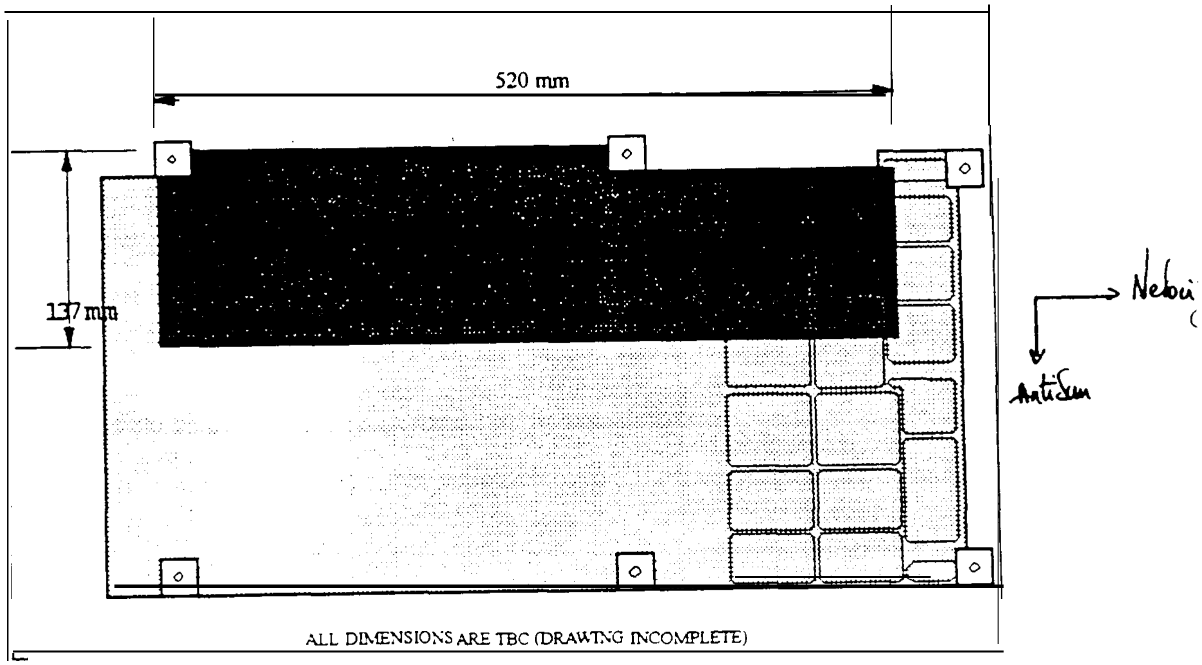


Figure 3.3/2 : HIRS/3 Baseplate Radiator Area

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red Emittance
	BOL	EOL	
Silver Teflon	0.09	TBD	0.76
Black Paint	0.96	TBD	0.91
Gold	0.33	TBD	0.03
VDA (vacuum deposited aluminium)	0.06	TBD	0.035
Aluminium Tape	0.25	TBD	0.04
Kapton (MLI ext)	0.35	TBD	0.53
white Paint	0.22	TBD	0.9
Black Honeycomb (cal. targets)	0.98	TBD	0.99

HIRS/3 Material Thermo-Optical Properties (TBC)

The radiative environmental temperatures for HIRS/3 are TBD.

3.3.3. Thermal Heat Capacity

The thermal heat capacity of HIRS/3 is TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

HIRS/3 **reduced** modelling in SINDA/TRASYS is under progress and should be completed by January 1995.

3.4. THERMAL ENVIRONMENT CONDITIONS

Nominal Operations (Earth Pointing)

HIRS/3 **scan mirror can** be parked at internal calibration target position, to protect the optics from direct Sun illumination from the instrument optical aperture.

Assuming a 105 K starting temperature, HIRS/3 coolers and detectors can survive a 14 minute direct Sun exposure.

The platform guarantees that there is no direct Sun illumination of the mounting plane radiator.

Direct illumination of the top radiator and of the back of the Earth cover shall be avoided

Safe Mode Operations (Sun Pointing)

The platform guarantees that there is no direct Sun illumination of the mounting plane radiator.

The behaviour of the top radiator in safe mode (instrument OFF, scanning motor running or not) is TBD.

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Power Sources

HIRS/3 requires to be power supplied with the following buses :

Power Bus	Number of Interfaces	Goals	TIROS Name
+ 28 V regulated power bus	4	One for the instrument primary power	Main regulated bus
		One for the scanning mechanism	Pulse load bus #1
		One for the filter chopper and internal outgas and filter housing heaters	Pulse load bus #2
		One for the temperature sensors when the instrument is off	Switched telemetry bus
+ 10 V regulated power bus	1	One for commands and digital B command verification telemetry	Interface Bus

In addition, a connection with a hearer power for the instrument baseplate shall be foreseen :

+ 28 V regulated heater power bus	1	One for the active thermal control (instrument baseplate)

Normal operation of the instrument is guaranteed if the voltage remains in the range 27 V - 29.5 V.

Power connection redundancy : TBD

Power Consumption and Modes

Basic Power Consumption	LEOP	Instr. ON	PLM Fii	PLM Safe	Outgas-sing
+ 28 V regulated power bus :					
Primary power	Off	8.1 W	Off	Off	8.1 w
Scanning mechanism	8.0 W	8.0 W	8.0 W	8.0 W	8.0 W
Filter Chopper. Heaters..	Off	6.6 w	off	Off	27.0 W
Temperature	0.03 W TBC	OTBC	OffTBC	OffTBC	OTBC
+ 10 V regulated power bus	Off TBC	0.1 w	Off TBC	Off TBC	0.1 w
TOTAL	8.03 w	22.8 w	8.0 W	8.0 W	43.2 W

The active thermal control shall be included in the platform budget. The need is :

+ 28 V regulated power bus	Off TBC	15.0 W (TBC)	TBD	TBD	TBD

4.2. COMMAND AND CONTROL INTERFACES

HIRS/3 synchronously operates with reference to a 1.248 MHz clock (master clock) and a 1 Hz clock Two synchronization signals are provided to HIRS/3 :

- a major frame synchronization pulse, every 32 sec.
- a 256 sec. calibration pulse.

26 pulse discrete commands (no level discrete command).

The duration of the pulse commands can be standardized at 60 ms.

4.3 SCIENCE DATA INTERFACES

8.320 kHz clock
Data enable signal
Digital A data interface

On TIROS, during one scan (i.e. 6.4 sec.), HIRS/3 generates 64 elements of 288 bit each (18 pairs of 8 bit words) The raw data rate is then 2.880 kbps.

However HIRS/3 generates 2304 octets per scan, which are encapsulated into one source packet. The resulting source packet total length is then 23 18 octets. The source packetized data rate is then 2.8975 kbps.

4.4. HOUSEKEEPING TELEMETRY

Analog housekeeping telemetry :	14	(2 during launch)
Digital housekeeping telemetry (digital B) :	14	
Switched telemetry bus thermistor interface	2	
Active thermal control thermocouple :	1	

4.5. CONNECTORS AND HARNESS

4.51. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCRIPTION

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.3.1. Quasi-Static Test

7.2.3.2. Dynamic Model Validation

N/A (HIRS/3 first natural **frequency is above 100** Hz).

7.2.3.3. Vibration Tests

HIRS/3 is the result of an evolution of instruments. HIRS/2 **was qualified to** levels much higher that the values used for HIRS/3 **Two alternatives are** possible :

- HIRS/3 could claim that the qualification levels of HIRS/2 wver HIRS/3. In this case HIRS/3 for METOP will need only acceptance testing according to the METOP **GICD** rules.
- HIRS/3 is different to HIRS/2 and cannot claim previous qualification. ln this case HIRS/3 will need qualification testing as defined in GICD.

If the path of only acceptance by METOP is chosen, it will be necessary to provide documentation that proves that the differences between HIRS/2 and /3 are small enough to justify this approach. It will be necessary to provide documentation detailing the mechanical qualification of the HIRS/2.

Next section will indicate the resulting test programmes for HIRS/3 that will result in both cases.

Sinus or Burst

Note : HIRS/3 first natural frequency is 188 Hz.

Status on NOAA levels

HIRS/2 was sinus tested to 11.5 g thrust axis and 7.5 in both lateral axes.

For HIRS/3, and according to NOAA documentation, no sinus test is necessary, but a qualification burst test shall be conducted by applying 19.44 g for the HIRS/3 in the three axes. An acceptance burst shall be conducted by applying 15.64 g in the three axis.

METOP Required Levels

The sinus qualification levels of HIRS/2 are below the qualification levels requested in GICD (15 g in the three axes). Nevertheless, the levels requested by NOAA for HIRS/3 during burst test, are above the 15 g sinus qualification levels.

Note the discrepancy in the duration : 0.5 s for NOAA versus the 1 s. requested by METOP GICD. The NOAA test frequency shall be clarified.

Random Vibrations

Status on NOAA *Levels*

HIRS/2 was qualified with a constant level of 0.085 g rms from 20 to 2000 Hz producing a total of 12.9 g rms.

As per NOAA documentation, for HIRS/3 the qualification level is 0.023 g^2/Hz from 20 to 2000. Total level is 6.7 g rms and 1 min of duration.

The acceptance levels are identical to qualification levels.

METOP Required Levels

The application of the METOP GICD levels produces for a MRS of 33 kg the following levels :

Qualification Levels

Frequency (Hz)	20to100	100 to 400	400 to 2000
Power Density	+3 dB/Oct	0.078 g^2/Hz	-3 dB/Oct.

The Qualification Levels required by METOP for HIRS/3 are below the Qualification Levels of HIRS/2. If HIRS/3 could claim that it has been qualified — through HIRS/2 — to levels more stringent than METOP ones, it will need only acceptance testing. The METOP required levels are then :

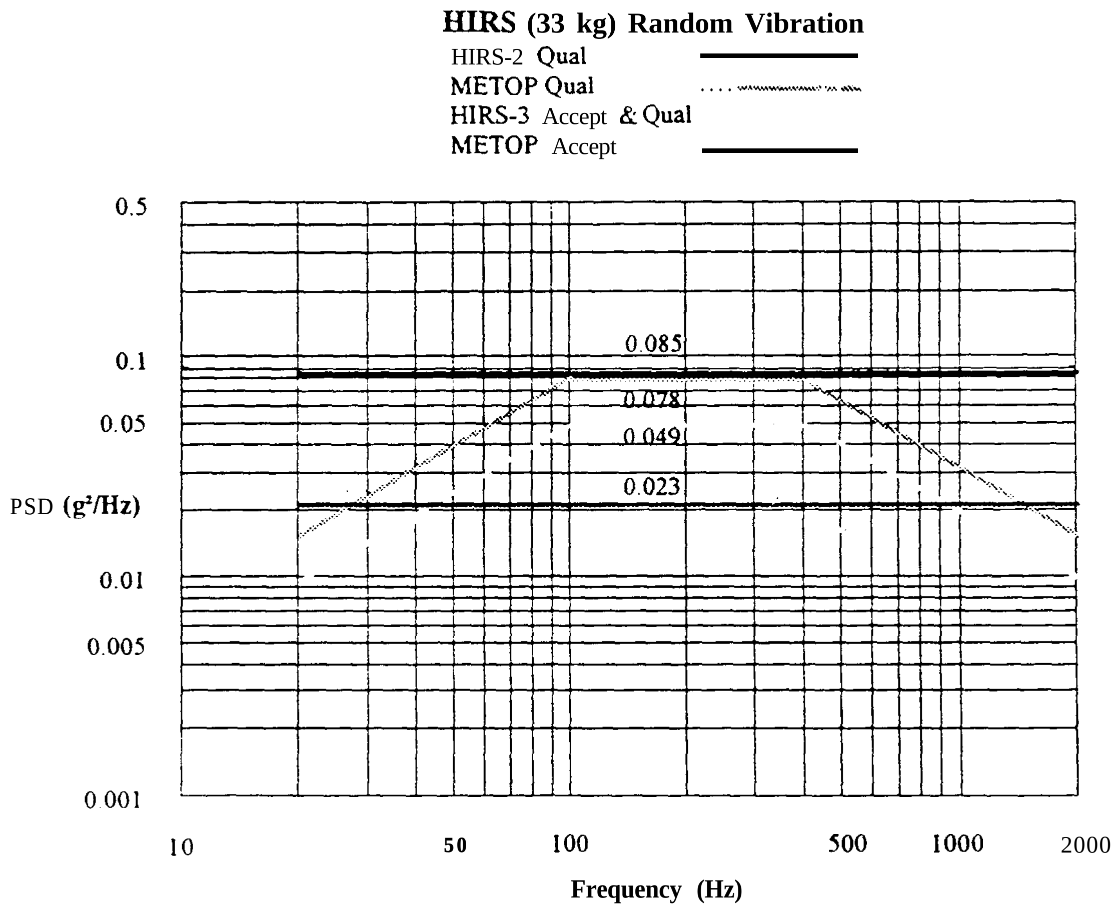
Acceptance Levels

Frequency (Hz)	20 to 100	100 to 400	400 to 2000
Power Density	+3 dB/Oct	0.049 g^2/Hz	-3 dB/Oct.

These levels are above HIRS/3 NOAA specified ones stated above. Then, for METOP valid acceptance testing — if previous qualification is claimed — the Random levels for HIRS/3 shall be increased from 0.023 to 0.049 g^2/Hz.

If the qualification of HIRS/2 cannot be applied, the levels to be used should be METOP qualification, i.e. 0.078 g^2/Hz

Levels can be seen in the graphic **below :**



7.2.3.4. Acoustic Test

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

For testing at spacecraft level, HIRS/3 will provide one Portable Test Unit (PTU) and two thermal vacuum targets (simulating space and Earth viewing) and their respective controllers. This equipment will operate at both 110 and 220 VAC, 50-60 Hz.

The possibility to have semi-automated test sequences with the PTU (or equivalent) is under evaluation.

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

None for METOP

9.1.2. Instrument Engineering Model (EM)

None for METOP

9.1.3. Instrument Proto-Flight Model (PFM)

None for METOP

9.1.4. Instrument Flight Model (FM)

2 Flight Models are to be delivered for METOP

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AN SITE

9.3. INSTRUMENT INTEGRATION

On TIROS platform an end-to-end testing at system level is performed in the thermal vacuum chamber. For HIRS/3, stimuli are required for cryogenic cooling and to simulate deep space and Barth scene conditions. The applicability to the METOP satellite is TBD. Note that only the infra-red channels require these stimuli, as the visible channels are optically simulated at ambient conditions.

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

HIRS/3 both mechanisms (scan mirror and filter wheel) shall be powered on during the launch phase. to off-load the bearings.

Telemetry shall be acquired prior to launch for health status and during launch.

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

HIRS/3 is continuously on along the orbit (duty cycle : 100%).

Commissioning and calibration : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

Once switched on, HIRS/3 nominally proceeds without any requirement for software or parameters update.

10.5. INSTRUMENT OPERATION MANUAL

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 3 years

Reliability : 0.828

IR detector lifetime : 5 years.

Flight Experience : about 4.5 years

12. PROGRAMME AND SCHEDULE

HIRS/3 is scheduled for a first flight on NOAA-K in 1995

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

AMSU-A1

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the AMSU-Al Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with AMSU-A1 responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

The Advanced Microwave Sounding Unit AMSU-A is a 15 channel instrument, consisting of two separate modules, AMSU-Al and AMSU-A2.

AMSU-Al is a 13 channel (numbers 3-15) scanning microwave instrument that is used to obtain data to calculate temperature and humidity profiles of the atmosphere from the Earth's surface up to the stratosphere.

AMSU-Al has two scanning reflectors with momentum compensation and provides sounding in 13 channels. The footprint at nadir is 50 km. The scanner has 30 Earth pointing positions with a separation of 3.333 deg. between them, one cold calibration position, and one warm calibration position. A full scan takes 8 seconds.

	Centre Frequency (MHz)	Bandwidth (MHz)	K NEΔT
3	50300	180	0.4
4	52800	400	0.25
5	53596 ± 115	170 / 2 p.b.	0.25
6	54400	400	0.25
7	54940	330	0.25
8	55500	330	0.25
9	57290.344 = F_{lo}	78	0.4
10	F_{lo} ± 217 MHz	36	0.4
11	F_{lo} ± 322.2 MHz ± 48 MHz	16	0.6
12	F_{lo} ± 322.2 MHz ± 22 MHz	8	0.8
13	F_{lo} ± 322.2 MHz ± 10 MHz	8	0.8
14	F_{lo} ± 322.2 MHz ± 4.5 MHz	3	1.2
15	89.0 GHz	6000	0.5

Scan Type : Step Starer
Scan Rate(s) : 8.0
IFOV (deg.) : 3.3 (circular)
Sampling Interval (deg): 3.3333

Earth View Pixels per Scan : **30**
Swath (deg. with respect to the nadir direction) : ± 48.333 deg.

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94, Iss. 2, dated Sept. 94

Reference Documentation

Unique Instrument Interface Specification for the AMSU-Al
Ref. IS-2617547 (MET0026), dated March 1992, rev. N
To be replaced by Rev. P, Feb. 93 for future phase

Performance Assurance Requirements for the Advanced Microwave Sounding Unit - A
Ref. S-48040 (MET0109), dated March 1992, rev. 0

AMSU-A I Thermal Interface Control and Instrument Configuration
Ref. 1333964 (MET0009 & 0010), dated 89

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

AMSU-Al consists of a single unit.

The Part Number and Identification Code of the AMSU-Al instrument are :

PART NO: T B D

ID CODE: TBD

The location of the labels giving these Part Numbers and Identification Codes are defined in the Mechanical Interface Control Drawing.

The total envelope is : L (Velocity) x W x H (Earth) 703 x 300 x 591 mm

Note that the overall dimensions shall be enlarged by 0.5 in. (1.3 cm) to include the MLI thermal blanket.

AMSU-A 1 does not have any deployable part

2.1.2. Mechanical Interface Control Drawing

The AMSU-Al instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The AMSU-Al configuration is illustrated in Figure 2.1/1

2.1.3. Mass Properties

Mass

The mass properties of the AMSU-Al instrument are given in the following table. The coordinate system used is the Instrument Mounting Interface Reference Frame, $F_{AMSU-A1}$, with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing) The directions of the $F_{AMSU-A1}$ axes are the same as the Spacecraft Reference Frame Fs.

Module /Unit	Basic Mass (± 0.1 kg, TBC)	Centre of Mass Location (± 5 mm)		
		$X_{AMSU-A1}$ (Sun)	$Y_{AMSU-A1}$ (Anti-velocity)	$Z_{AMSU-A1}$ (Zenith)
AMSU-A 1	53.3 kg (117.5 lb)	- 158.8 mm	+ 278.4 mm	- 233.7 mm

AMSU-A I Mass Properties

The above mass includes the TIROS bracket mass (TBC).

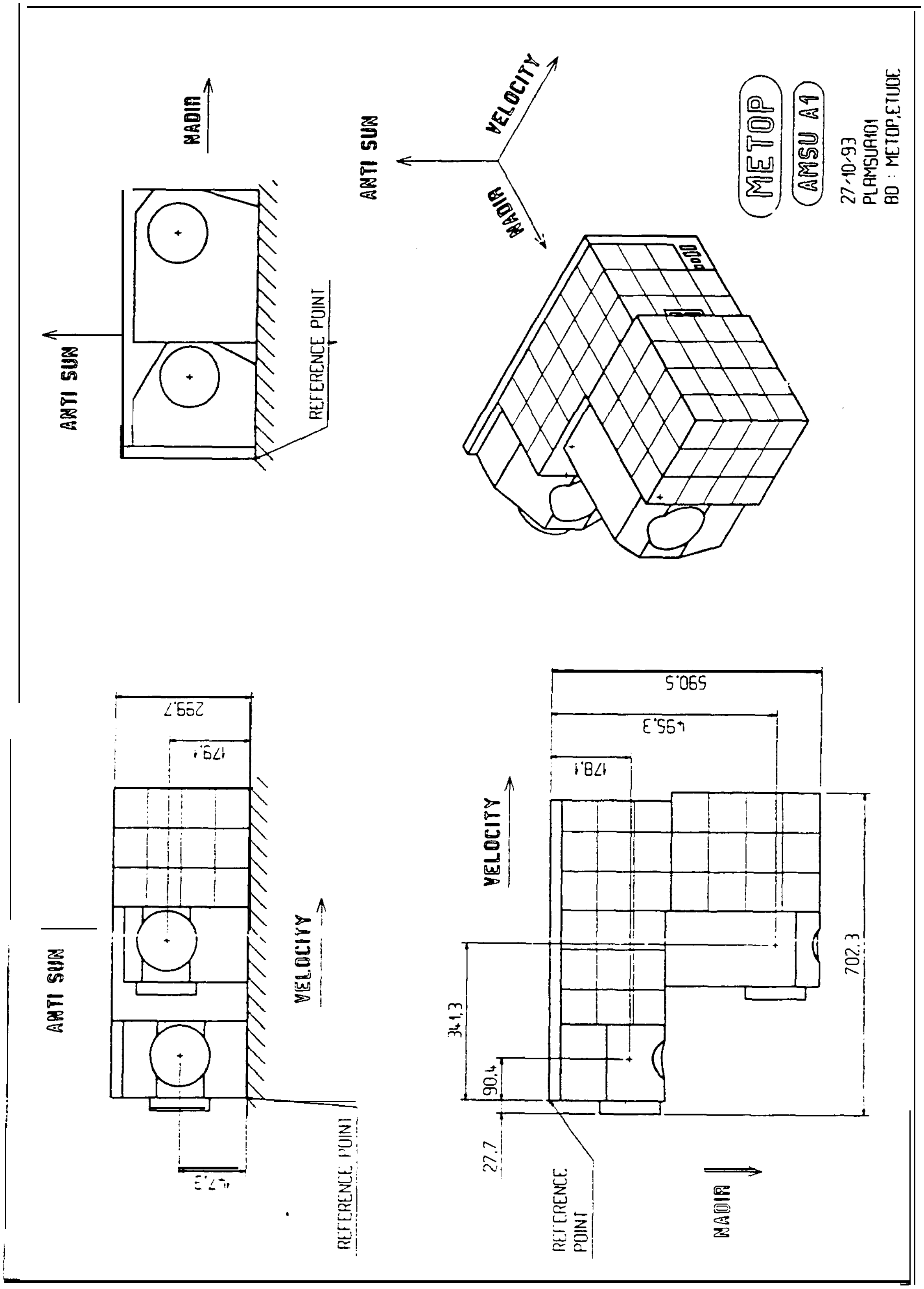


Figure 2.1/1 : AMSU-A1 Configuration

Moments of Inertia

The AMSU-A1 moments of inertia are as follows. The coordinate system used is the Instrument Mounting *Interface* Reference Frame, $F_{AMSU-A1}$ (TBC), with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing). The directions of the $F_{AMSU-A1}$ axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

Module /Unit	Moments of Inertia (kg.m²)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
AMSU-A 1	3.1898	1.7558	2.4582	TBD	TBD	TBD
	10900	6000	8400	lb . sq in		

AMSU-AI Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

TBD

2.1.4.2. Continuous and Recurring Transient Events

AMSU-A1 step scanning is uncompensated. The disturbance torque which is illustrated in Figure 2.1.4/1 corresponds to time measurements. The disturbance consists of a torque profile on the Y axis (velocity, scenes are scanned from Sun, through Earth, to space) divided into 30 Earth dwells, a cold calibration and a hot calibration over a period of 8 sec. It is assumed that there is zero disturbance torque on the other axes.

The static and dynamic unbalance values on each axis are TBD.

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

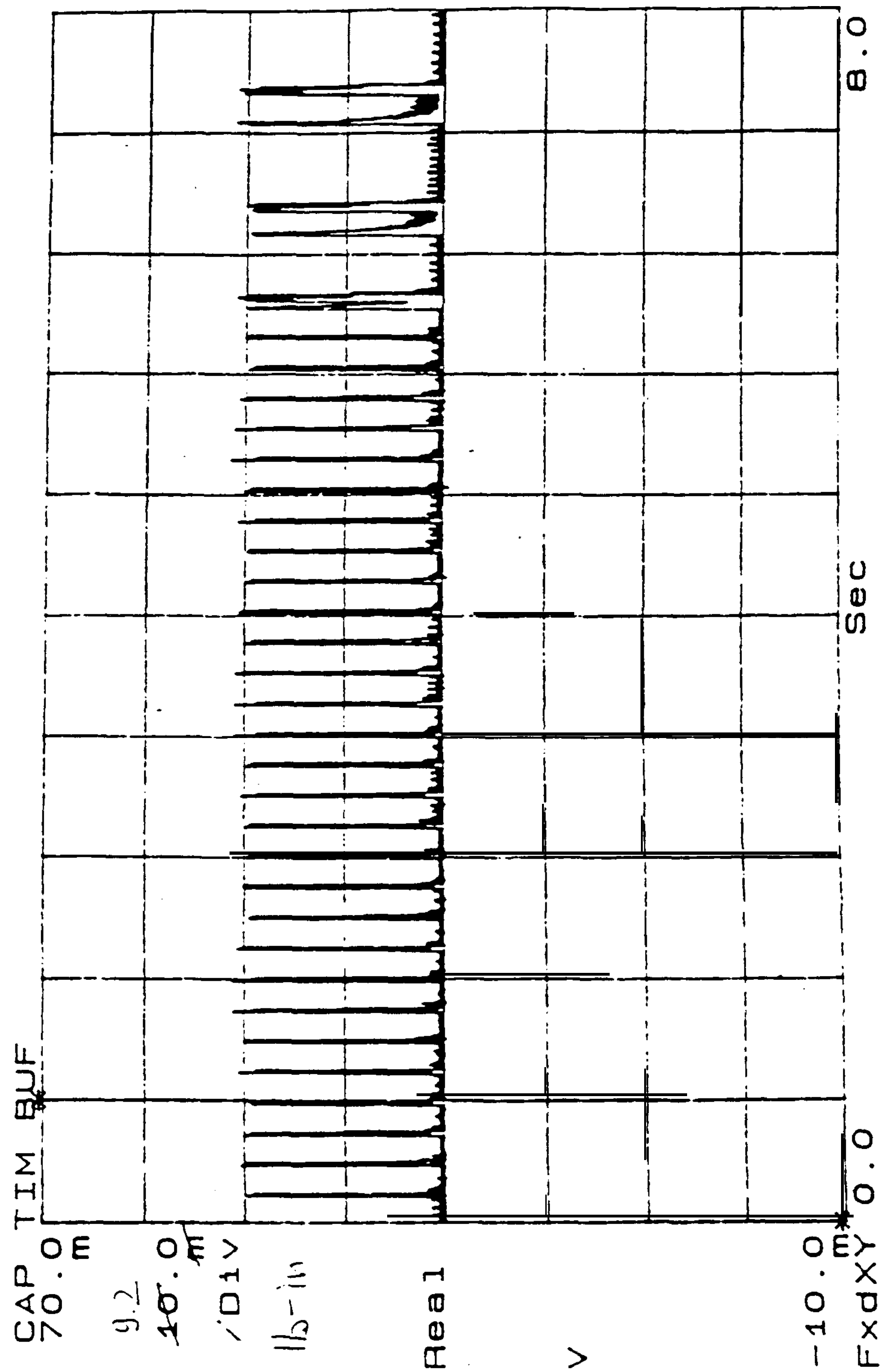


Figure 2. 1.4/1 : AMSU-A I Uncompensated Torque Profile

2.1.5. Field of View Definition

AMSU-A1 boresight is defined as the nadir direction. The instrument field of view definition is :

- two vertex (Cf. drawing)
- Spacecraft provision :
  - cross-track scan plane : from 87/90 deg. anti-Sun-wards to 52/56 deg. Sunwards.

    This is the general envelope for 3.5/7° margin + 48.333" Sunwards + 48.333" anti-Sunwards + 35" anti-Sun calibration + 3.5/7° margin
  - Orbit plane : ± 7 deg. (TBC)

AMSU-Al field of view is illustrated in Figure 2.1.5/1.

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

AMSU-Al is hard mounted with two alignment pins and multiple bolts through an Aluminium baseplate.

The AMSU-A1 instrument is mounted to the platform panel using a Specific interface Hardware. Thermal isolation may be utilised at either the instrument interface or at the interface of the Specific Interface Hardware to the platform.

The bolt size, length and torque required to mount the instrument are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
AMSU-A 1				

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for AMSU-Al is given in the Mechanical Interface Control Drawing, TBD (Cf. drawing)

2.2.3. Mounting Surfaces

AMSU-Al is mounted on its +X (METOP axis) side. which is compliant with a dedicated stand accommodation supplied by the Platform (Specific Interface Hardware). The flatness of the mounting surfaces does not exceed TBD mm in 100 mm The surface roughness of the mounting surfaces are TBD pm. Each mounting foot has an area of TBD mm^2

2.2.4. Materials

The material of the AMSU-Al baseplate is aluminium alloy. A TBD finish is applied to the material at the mounting area. The Specific Interface Hardware is alummium skinned honeycomb (TBC).

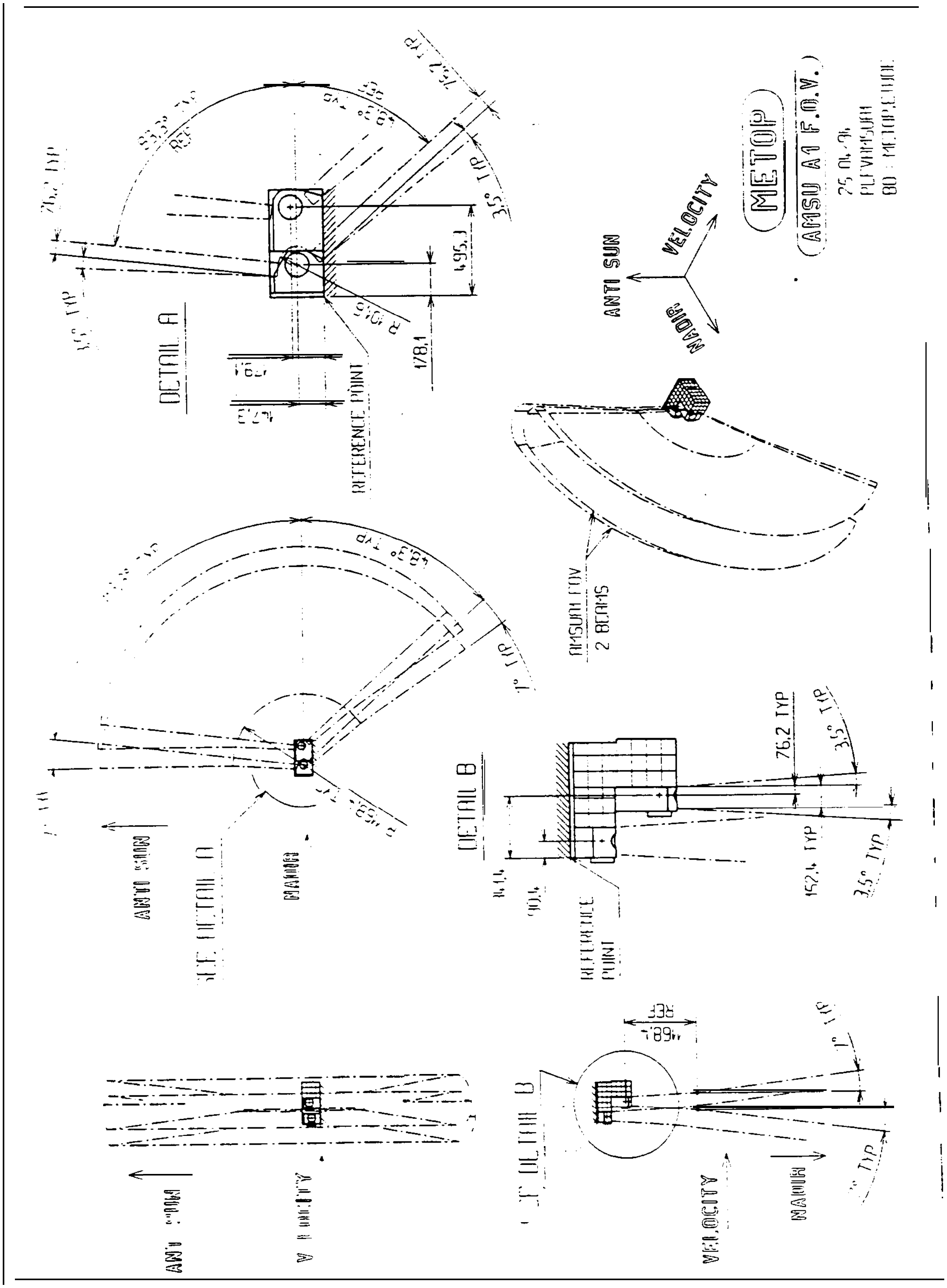


Figure 2.1.5/1 : AMSU-A1 Field of view

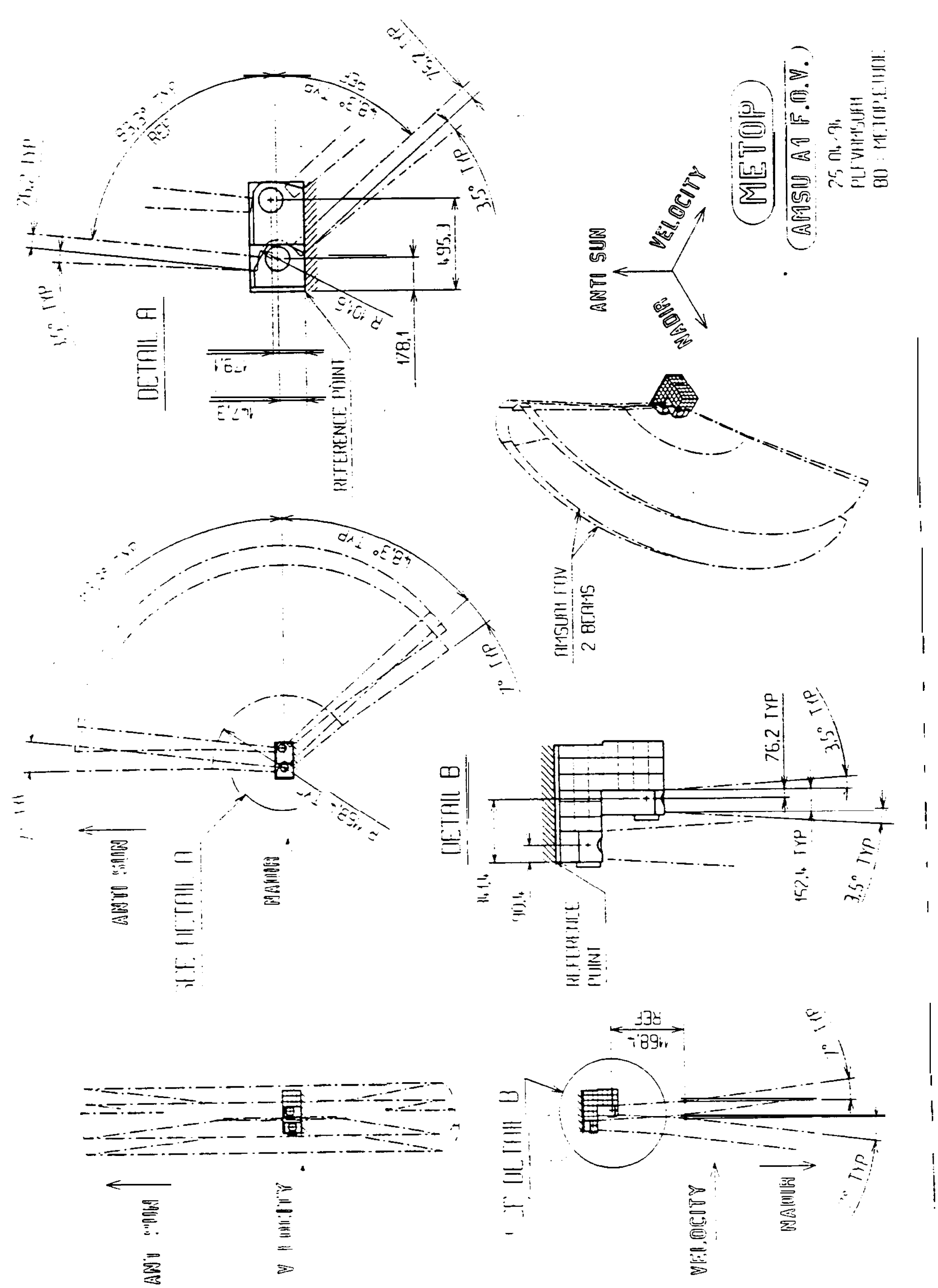


Figure 2.1.5/1 : AMSU-A1 Field of view

- Co-alignment Requirements : ± 0.30 deg. (3σ) with respect to **AMSU-A2**
± 0.30 deg. (3σ) with respect to MHS

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.52. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequency of the AMSU-Al instrument is 125 Hz. this value having been established by test. Note that this value includes the TIROS side bracket (TBC).

As this frequency is above the 100 Hz limit, no mechanical interface model is required

2.6. MECHANISMS

2.6.1. Functional Description

Mechanical step-scanning (2 antennae) mechanism : TBD

2.6.2. Performances

There is no launch constraint. Permanent magnetic motor detents prevent reflector motions during test_ shipment and launch.

2.7. PYROS

None

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

2 antenna covers and 2 feed horn covers

2.8.2. Removable Covers (Non-Flight Items)

Cf. § 2.8.1.

2.8.3. Deployable Covers (Flight Items)

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

AMSU-Al **is a Category** A instrument. Its thermal control is autonomous with dedicated radiators on the instrument sides.

3.1.2. Thermal Control Philosophy

Normal Operation

During nominal operating modes, AMSU-Al uses passive radiators to reject its heat to space.

Contingency Modes

During the contingency modes the instrument is switched off, and internal heaters are only required to supply make-up heat. The temperature of AMSU-Al will be maintained within its survival limits by these heaters which are controlled using thermostats with a **lower set point of -20 deg. C.**

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the AMSU-Al instrument are defined below. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C	Operation		Non-Operation		Switch-On
AMSU-Al	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**
Acceptance	+8	+28	-30	+66	-20
Qualification (TBC)	-20	+40	-35	+71	-25

Stability **Requirements**

There is no stability requirement for AMSU-A 1.

3.2.2. Radiative **Interfaces**

The AMSU-Al passive radiator areas and the thermal views to space are given below.

The radiator areas shall be confirmed since other values can be found in the documentation, such as

-Z METOP axis	160 sq. in., i.e. 1032,256 cm^2
-Y METOP axis	373 sq. in., i.e. 2406,45 cm^2
-X METOP axis	336 sq. in., i.e. 2 167,74 cm^2

Radiator Face	Radiator Part	Area (m^2)	Required View Factor	Calculated View Factor	Calculated Gebhart
-zs		0.0756 TBC	1.0	0.9693	0.977 1
-Ys	-zs	0.0957 TBC	0.91	0.844	0.8719
-Ys	+ zs	0.08 13 TBC	0.78	0.5547	0.6488
-xs	-zs	0.0804 TBC	0.66	0.8113	0.8405
-xs	+zs	0.1371 TBC	0.11	0.6377	0.6792

AMSU-Al Radiator Areas and Thermal Fields of Vi

3.2.3. Heater Power Budgets

The heater power budgets for the AMSU-Al instrument are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
AMSU-Al			40.0	40.0

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipation of the AMSU-Al instrument is constant throughout the orbit and is :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
AMSU-Al	N/A	97.2 (TBC)	97.2 (TBC)	0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the AMSU-Al instrument for different cases are :

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
AMSU-Al	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

3.2.6. Thermo-Elastic Interface

The AMSU-Al instrument has an aluminium baseplate with a coefficient of thermal expansion of 25 x 10^{-6} / deg. C (TBC). The interfacing structure for the AMSU-A1 instrument is aluminium (TBC) with a coefficient of thermal expansion of 25 x 10" / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interface is the instrument baseplate which is defined in the Mechanical Interface Control Drawing (TBD), and in § 2.2.3.

The total thermal conductance between the AMSU-Al instrument and the Specific Interface Hardware is TBD W/K.

The calculated temperatures at the AMSU-A1 conductive interfaces are TBD

3.3.3. Radiative Interfaces

The external surfaces of the AMSU-A1 instrument, and the finishes used are given in the Thermal Interface Drawing (TBD). The AMSU-A 1 *thermal* coatings are illustrated in Figure 3.3/1.

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	**Solar Absorptance**		**Infra-Red Emittance**
	BOL	**EOL**	
Silver Teflon Tape	0.07	0.17	0.65
Black Anodize	0.52	0.54	0.84
SSM	0.07	0.12	0.79
Gold Plate/Gold Tape	0.28	0.32	0.04
Chemical Conversion Coating	0.47	0.55	0.14
MLI (SSM external)	0.07	0.17	0.65

AMSU-A1 Material Thermo-Optical Properties (TBC)

The radiative environmental temperatures for AMSU-A 1 are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacity of AMSU-A1 is TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

AMSU-A1 thermal model exists in SINDA/TRASYS. It has been converted to ESATAN/ESABASE and will soon undergo testing.

3.4. THERMAL ENVIRONMENT CONDITIONS

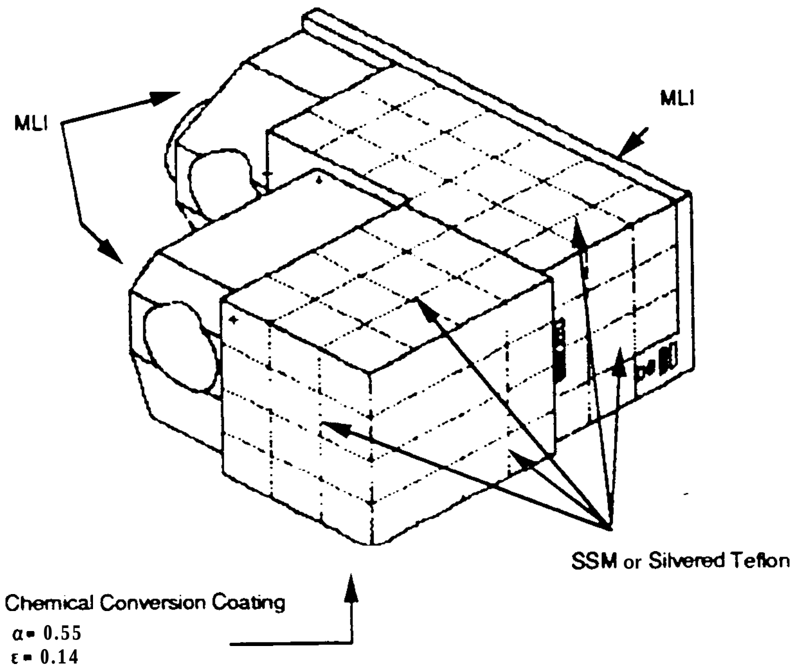


Figure 3.3/1 : AMSU-A1 Thermal Coatings

4. ELECTFUCAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Power **Sources**

AMSU-Al requires to be power supplied with the following buses :

Power Bus	Number of Interfaces	Goals	TIROS Name
+ **28 V** regulated power bus	3	One for the instrument primary power	Main regulated bus
		One for the motors and heaters	Pulse load bus
		One for the temperature sensors when the instrument is off	Switched telemetry bus
+10 V regulated power bus	1	One for commands and digital B command verification telemetry	Interface Bus

Voltage range : TBD

Power connection redundancy : TBD

Power Consumption **and Modes**

Basic Power Consumption	LEOP	Instr. ON	PLM Fix	PLM Safe
+ **28 V** regulated power bus :				
Primary power	Off	82.0 W	Off	Off
Motors and heaters	Off	6.0 W	Off	Off
Temperature	Off TBC	0.2 w	OffTBC	OffTBC
+10 V regulated power bus	OffTBC	0.1 W	OffTBC	**OffTBC**
TOTAL	**o w TBC**	**88.3 w**	**0 w TBC**	**o w TBC**

4.2. COMMAND AND CONTROL INTERFACES

AMSU-A1 synchronously operates with reference to a 1.248 MHz clock (master clock). One 8 sec synchronization signal shall be provided by the platform.

AMSU-A 1 requires 4 pulse discrete and 10 level discrete commands from the platform.

1 survival heater On / Off command.

4.3 SCIENCE DATA INTERFACES

16.320 kHz clock
Data enable signal
Digital A data interface

In full scan mode, AMSU-Al generates 1244 bytes of measurement data per scan (i.e. during 8 sec.). On TIROS, 26 words in the AIP minor frame (so for 100 ms) are allocated to AMSU-Al, and are filled with 13 pairs of 8-bit words. Hence an apparent raw data rate of 2.080 kbps.

The encapsulation of the 1244 octets within one source packet results in a source packet total length of 1258 octets.

The packetized data rate is then 1.258 kbps.

4.4. HOUSEKEEPING TELEMETRY

Analog housekeeping telemetry :	21
Digital housekeeping telemetry (digital B) :	12
Switched telemetry bus thermistor interface :	6

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCRIPTION

RF **Receiver Characteristics**

The AMSU-A 1 RF receiver has the following specified characteristics .

CF	BW	Sensitivity
50.3 GHz	180 MHz	-96.7 dBm

AMSU-A1 can stand the full POEM-I (165 V/m) field strength.

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

AMSU includes a lubricant reservoir for the bearings that is not sealed and may evaporate (to be clarified). A class 100 000 room is sufficient.

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. hleteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

None for METOP.

9.1.2. Instrument Engineering Model (EM)

None for METOP.

9.1.3. Instrument Proto-Flight Model (PFM)

None for METOP.

9.1.4. Instrument Flight Model (FM)

2 Flight Models are to be delivered for METOP.

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

The bearing lubricant reservoir needs to be purged on ground with N2 (to be clarified)

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

AMSU-Al is continuously on along the orbit (duty cycle : 100%).

Commissioning and calibration : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

Once switched on. AMSU-A1 nominally proceeds without any requirement for software or parameters update

10.5. INSTRUMENT OPERATION MANUAL

Fix **and Safe** Modes

One command witches the Instrument off and internally parks the reflectors

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 3 years

Reliability : 0.7 for 3 years

In-Flight Experience : None

12. PROGRAMME AND SCHEDULE

AMSU-Al IS scheduled for a first flight on NOAA-K in 1995

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

AMSU-A2

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the AMSU-A2 Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with AMSU-A2 responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

AMSU-A2 is the second module of the Advanced Microwave Sounding Unit. It **is a two channel scanning microwave** instrument (channel numbers 1 and 2), that is used to obtain data to calculate temperature and humidity profiles of the atmosphere from the Earth's surface up to the stratosphere.

AMSU-A2 has one rotational scanning reflector without momentum compensation and provides sounding in two channels. The footprint at nadir is SO km. The scanner has 30 Earth pointing positions with a separation of 3.333 deg. between them, one cold calibration position, and one warm calibration position. A full scan takes 8 seconds.

	Centre Frequency (MHz)	Bandwidth (MHz)	K NEAT
1	23800	270	0.3
2	3 1400	180	0.3

Scan Type : Step Starer
scan Rate (s) 8.0
IFOV (deg.) : 3.3 (circular)
Sampling Interval (deg.) : 3.3333
Earth **View Pixels per Scan** : **30**
Swath (deg. with respect to the nadir direction) : **± 48.333 deg**

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMSfMETISPEIJLDIl59.94. Iss. 2, dated Sept. 94

Reference Documentation

Unique Interface Specification for the AMSU-A2
Ref. IS-2624483 (MET0026). dated March 1992, rev. L
To be replaced by Rev. M. Feb. 93 for future phase

Performance Assurance Requirements for the Advanced Microwave Sounding Unit - A
Ref S-480-40 (MET0 109). dated March 1992. rev. 0

AMSU-A2 Thermal Interface Control and Instrument Configuration
Ref. 1333965 (MET001 1& 0012). dated 89

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

AMSU-A2 consists of a single unit.

The **Part Number** and **Identification Code** of the AMSU-A2 instrument are :

PART NO: T B D

ID CODE: TBD

The **location** of the **labels giving these Part Numbers** and Identification Codes are defined in the Mechanical Interface Control Drawing:

The total envelope is : L (Velocity) x W x H (Earth) 614 x 736 x 684 mm.

Note that the overall dimensions shall be enlarged by 0.5 in. (1.3 cm) to include the MLI thermal blanket.

AMSU-A2 does not have any deployable part.

2.1.2. Mechanical Interface Control Drawing

The AMSU-A2 instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The AMSU-A2 configuration is illustrated in Figure 2.1/1.

2.1.3. Mass Properties

Mass

The mass properties of the AMSU-A2 instrument are given in the following table. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, $F_{AMSU-A2}$, with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf drawing). The directions of the $F_{AMSU-A2}$ axes are the same as the Spacecraft Reference Frame Fs.

Module /Unit	**Basic Mass (± 0.1 kg, TBC)**	**Centre of Mass Location (± 5 mm)**		
		$X_{AMSU-A2}$ (Sun)	$Y_{AMSU-A2}$ (Anti-velocity)	$Z_{AMSU-A2}$ (Zenith)
AMSU-A2	47.4 kg (104.5 lb)	+ 392.9 mm (TBC)	- 309.1 mm (TBC)	- 312.4 mm (TBC)

AMSU-A2 Mass Properties

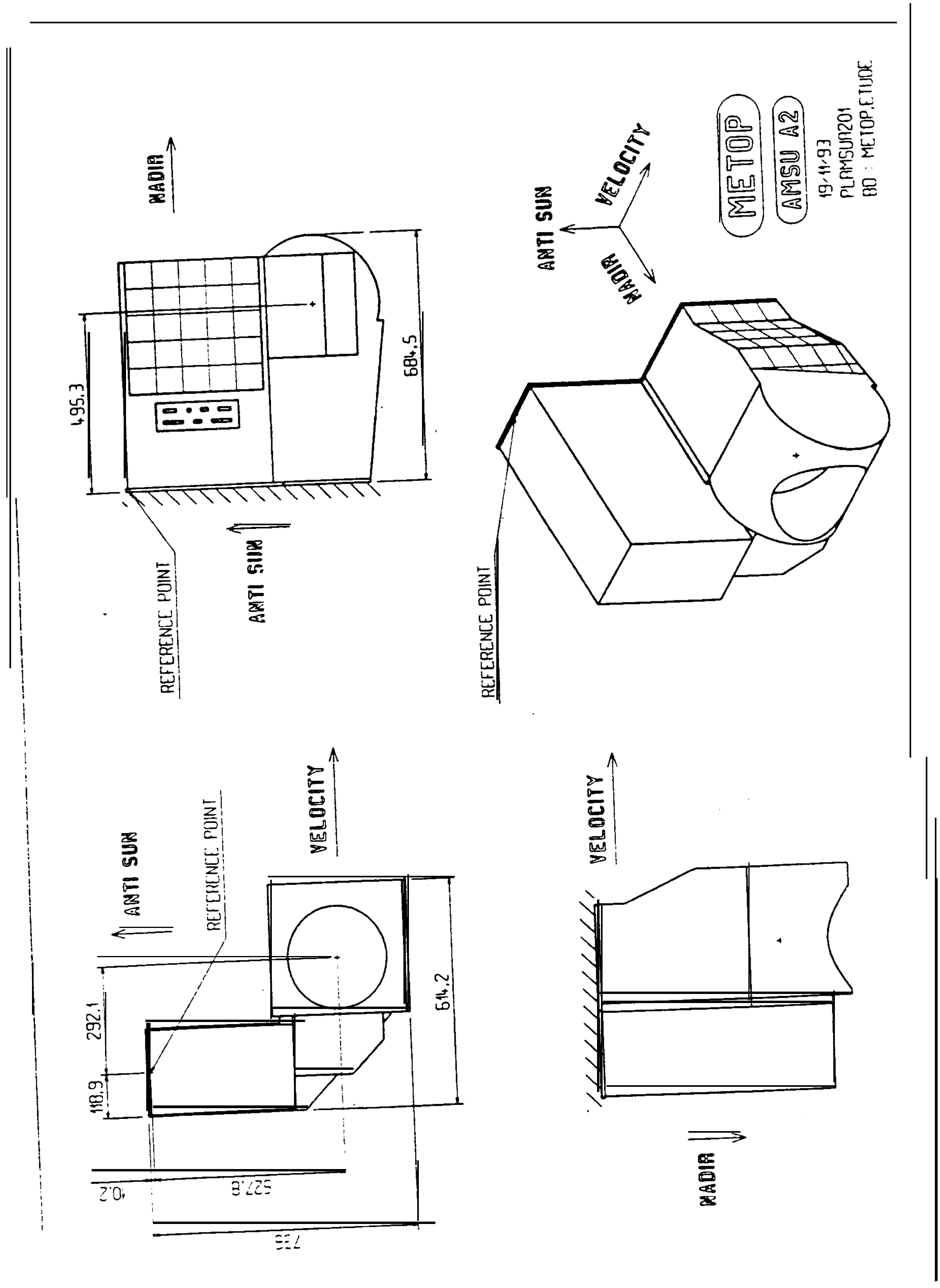


Figure 2.1/1 : AMSU-A2 Configuration

Moments of Inertia

The AMSU-A2 moments of inertia are as follows. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, $F_{AMSU-A2}$ (TBC), with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing). The directions of the $F_{AMSU-A2}$ axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

Module /Unit	Moments of Inertia ($kg.m^2$)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
AMSU-A2	2.780	3.307	3.365	TBD	TBD	TBD
	9500	11300	11500	lb . sq in		

AMSU-A2 Moments of Inertia (TBC)

2.1.4. Instrument Induced Disturbances

2.1.4.1. **Non Recurring Transient Events**

TBD

2.1.4.2. Continuous and Recurring Transient Events

AMSU-A2 is 90 to 100 % momentum compensated. The residual torque over 8 sec. along the Y (velocity) axis (scan from Sun. through Earth, to space) is illustrated in Figure 2.1.4 (from ASCII file time measurement). It is assumed that there is zero residual torque on the other axes.

The static and dynamic unbalance values on each axis are TBD.

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

2.1.5. Field of View Definition

AMSU-A2 boresight is defined as the nadir direction. The instrument field of view definition is :

- vertex
- Spacecraft provision
  - cross-track scan plane : from 87/90 deg. anti-Sun-wards to 52/56 deg. Sunwards.

    This is the general envelope for 3.5/7° margin + 48.333" Sunwards + 48.333" anti-Sun-wards + 35° anti-Sun calibration + 3.5/7° margin
  - Orbit plane : ± 3.5/7 deg. (TBC)

AMSU-A2 field of view is illustrated in Figure 2.1.5/1

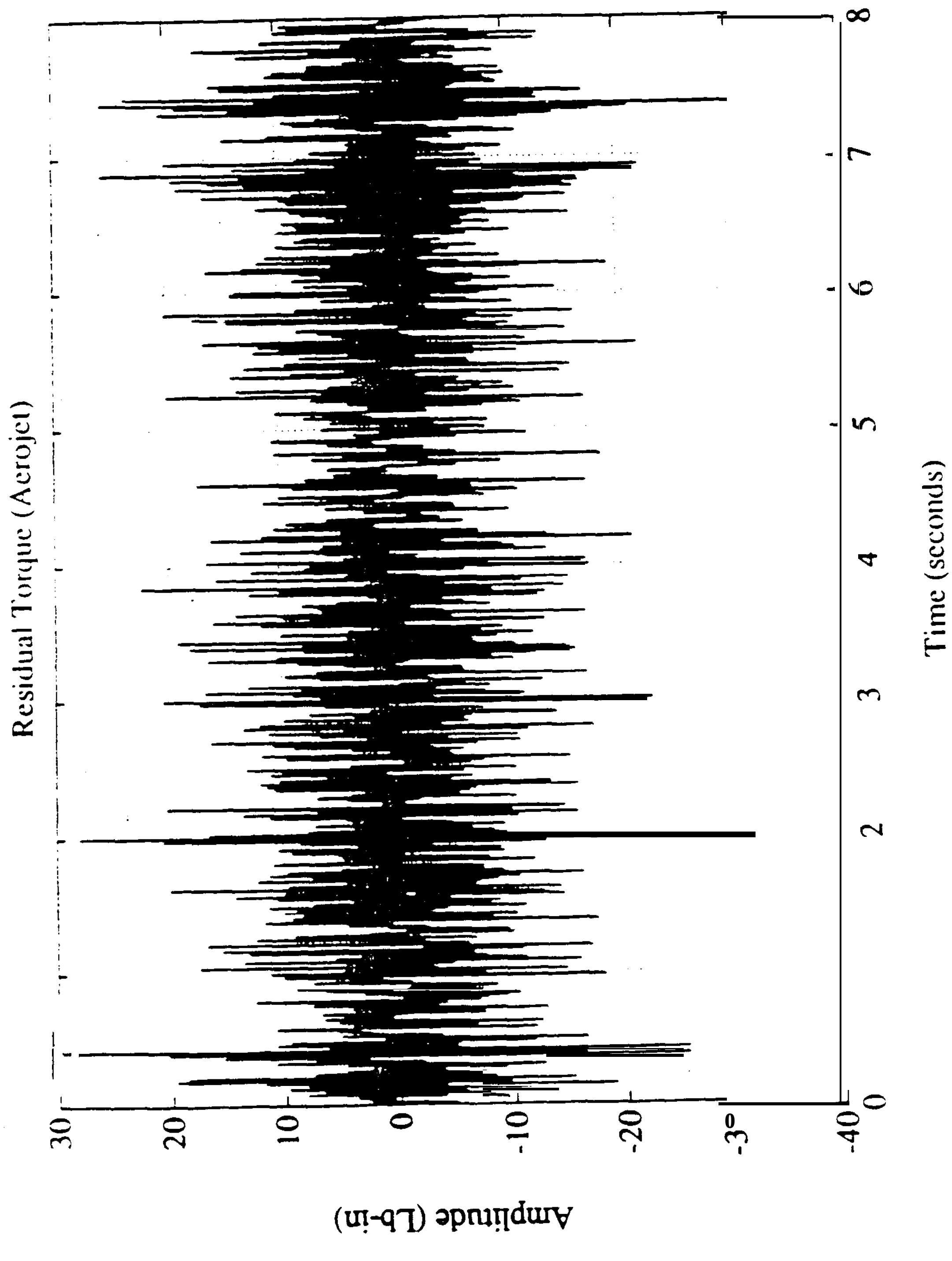


Figure 2.1.4 : AMSU-A2 Residual Torque

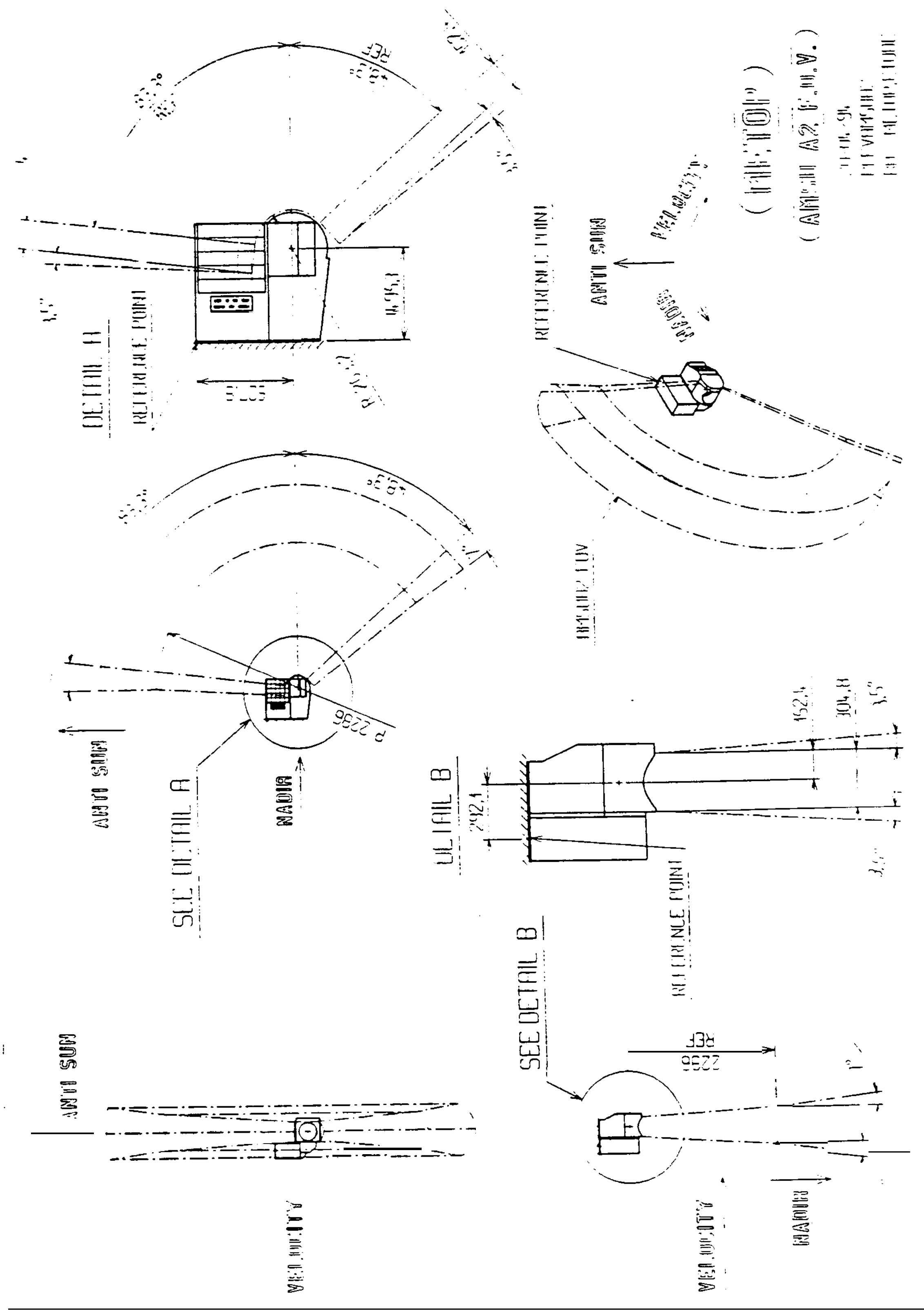


Figure 2.1.5/1 : AMSU-A2 Field of View

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The AMSU-A2 instrument is mounted to the platform panel using Specific interface Hardware which are flexible mounts. Thermal isolation may be utilised at either the instrument interface or at the interface of the Specific interface Hardware to the platform.

The bolt size, length and torque required to mount the instrument to this hardware are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
AMSU-A2				

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for AMSU-A2 is given in the Mechanical Interface Control Drawing, TBD (Cf. drawing).

2.2.3. Mounting Surfaces

AMSU-A2 **is** mounted using its baseplate which is on the nadir side (+Z, METOP) of the platform.. The flatness of the mounting surfaces does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of TBD mm^2.

The accommodation shall be compliant with the use, on ground, of a reflector cover (Cf. § 2.8.1).

2.2.4. Materials

The material of the AMSU-AZ baseplate is aluminium alloy. A TBD finish is applied to the material at the mounting area. The Specific Interface Hardware is Titanium or INVAR (TBC).

2.2.5. Interface Loads

The mounting bolds can withstand up to 5.6 Nm (50 in.lb) maximum The calculated interface loads induced by the AMSU-A2 instrument are

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
AMSU-A2 Baseplate				

2.2.6. Accessibility

Accessibility **in the** +Ys **direction is required** as **The** connectors are on the +Ys side of the Instrument.

2.2.7. Grounding Point

The locations of the grounding points on the AMSU-AZ instrument are defined in TBD.

2.3. POINTING

The pointing requirements for the AMSU-A2 instrument are expressed at the Instrument Mounting Interface Reference Frame $F_{AMSU-A2}$

Absolute Pointing Error (Accuracy) :	± 0.15 deg. (3σ)
Absolute Measurement Error (Knowledge) :	± 0.10 deg. (3σ)
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical Interface Control Drawing, TBD. The cube has two alignment surfaces of size TBD mm^2 which are viewed from the spacecraft TBD axes.

The cube shall be covered with a cover in accordance with TBD prior to launch.

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

The co-alignment requirements are expressed between the Instrument Mounting Interface Reference Frames (F_{MI}) of each instrument.

AMSU-A2 shall be co-aligned with AVHRR/3 to within ± 0.05 deg. (3σ).

Note that the following information can be found in the UIIS (Cf. § 1.3.) :

- Co-alignment Requirements : ± 0.30 deg. (3σ) with respect to AMSU-Al
  ± 0.36 deg. (3σ) with respect to MHS

2.5. STRUCTURAL DESIGN

2.51 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.53. Safety Factors

The calculated safety factors are TBD

2.54. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequency of the AMSU-A2 instrument is 82 Hz, this value having been established by test. The second and third frequencies are 120 and 138 Hz (data are only available up to 150 Hz).

As this frequency is below the 100 Hz limit. a mechanical interface model is required.

Structural Mathematical Model

A 100-node model exists and is correlated with the 82 Hz resonance.

2.6. MECHANISMS

2.6.1. Functional Description

Mechanical step-scanning (1 antenna) mechanism : TBD.

2.6.2. Performances

There is no launch constraint. Permanent magnetic motor detents prevent reflector motions during test. shipment and launch.

2.7. PYROS

None.

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

1 antenna cover and feed horn cover.

2.8.2. Removable Covers (Non-Flight Items)

Cf. § 2.8.1.

2.8.3. Deployable *Covers* (Flight Items)

None.

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

AMSU-A2 is a Category A instrument. Its thermal control is autonomous with dedicated radiators on the instrument sides.

3.1.2. Thermal Control Philosophy

Normal Operation

During nominal operating modes, AMSU-A2 uses passive radiators to reject its heat to space.

Contingency Modes

During the contingency modes the instrument is switched off, and internal heaters are required to supply make-up heat. The temperature of AMSU-A2 will be maintained within its survival limits by these heaters which are controlled using thermostats with a lower set point of -20 deg. C.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, nonoperating and switch-on temperatures for the AMSU-A2 instrument are defined below. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C	**Operation**		**Non-Operation**		**Switch-On**
AMSU-A2	Min.	**Max.**	Min.	**Max.**	Min.
Acceptance	+6	+28	-30	+66	-20
Qualification (TBC)	-20	+40	-35	+71	-25

Stability Requirements

There is no stability requirement for AMSU-A2.

3.2.2. Radiative Interfaces

The AMSU-A2 passive radiator areas and the thermal views to space are given below.

The radiator areas shah be confirmed since other values can be found in the documentation. such as :

-Y METOP axis 79 sq in.. i.e. 509.7 cm'
+Y METOP axis 183 sq. in.. i.e. 1 180.7 cm^2

Radiator Face	Area (m^2)	Required View Factor	Calculated View Factor	Calculated Gebhart
-Ys	0.1013 TBC	0.98	0.8509	0.8801
+Ys	0.1188 TBC	0.51	0.4837	0.5754

AMSU-A2 Radiator Areas and Thermal Fields of View

3.2.3. Heater Power Budgets

The heater power budgets for the AMSU-A2 instrument are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
AMSU-A2			15.0	15.0

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipation of the AMSU-A2 instrument is constant throughout the orbit and is :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency I Safe Mode
AMSU-A2	N/A	41.0 (TBC)	41.0 (TBC)	0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the AMSU-A2 instrument for different cases are :

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
AMSU-A2	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

3.2.6. Thermo-Elastic Interface

The AMSU-A2 instrument has an aluminium baseplate with a coefficient of thermal expansion of 25 x 10^{-6} / deg. C (TBC). The material of the interfacing brackets is inconel (TBC). The PLM mounting panel is aluminium honeycomb with CFRP skins with a coefficient of thermal expansion of 2.0 x 10^{-6} / deg. C (TBC).

33. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interface is the instrument baseplate which is defined in the Mechanical Interface Control Drawing (TBD) and in § 2.2.3.

The total thermal conductance between the AMSU-A2 instrument and the platform is TBD W/K.

The calculated **temperatures** at the AMSU-A2 **conductive interfaces are** TBD.

3.3.3. Radiative Interfaces

The external surfaces of the AMSU-A2 instrument, and the finishes used are given in the Thermal Interface Drawing (TBD). The AMSU-A2 thermal coatings are illustrated in Figure 3.3/1.

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red Emittance
	BOL	EOL	
Silver Teflon Tape	0.07	0.17	0.65
Gold Plate / Gold Tape	0.28	0.32	0.04
Aluminium Kapton Tape (VDA)	0.12	0.17	0.05
MLI (SSM external)	0.07	0.17	0.65
Chemical Conversion Coating	0.47	0.55	0.14

AMSU-A2 Material Therm&Optical Properties (TBC)

The radiative environmental temperatures for AMSU-A2 are TBD

3.3.4. Thermal Heat Capacity

The thermal heat capacity of AMSU-A2 is TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

AMSU-A2 thermal model exists in SINDA/TRASYS. Conversion to ESATAN/ESABASE is being performed.

3.4. THERMAL ENVIRONMENT CONDITIONS

Radiator Face	Area (m^2)	Required **View Factor**	Calculated View Factor	Calculated Gebhart
-Ys	0.1013 TBC	0.98	0.8509	0.8801
+Ys	0.1188 TBC	0.51	0.4837	0.5754

AMSU-A2 ***Radiator Areas and Thermal Fields of View***

3.2.3. Heater Power Budgets

The heater power budgets for the AMSU-A2 instrument are :

Module /Unit	**Heater Power Budget (Watts)**			
	Operating Hot Case	**Operating** Cold Case	**Off** Cold Case	**Off** Safe Mode
AMSU-A2			15.0	15.0

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipation of the AMSU-A2 instrument is constant throughout the orbit and is :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency I Safe Mode
AMSU-A2	N/A	41.0 (TBC)	41.0 (TBC)	0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the AMSU-A2 instrument for different cases are :

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off **Cold Case**
AMSU-A2	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

3.2.6. Thermo-Elastic Interface

The AMSU-A2 instrument has an aluminium baseplate with a coefficient of thermal expansion of 25 x 10^{-6} / deg. C (TBC). The material of the interfacing brackets is inconel (TBC). The PLM mounting panel is aluminium honeycomb with CFRP skins with a coefficient of thermal expansion of 2.0 x 10^{-6} / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interface is the instrument baseplate which is defined in the Mechanical Interface Control Drawing (TBD) and in $2.23.

The total thermal conductance between the AMSU-A2 instrument and the platform is TBD W/K.

The calculated **temperatures at the** AMSU-A2 **conductive interfaces are** TBD.

3.3.3. Radiative Interfaces

The external surfaces of the AMSU-A2 instrument, and the finishes used are given in the Thermal Interface Drawing (TBD). The AMSU-A2 thermal coatings are illustrated in Figure 3.3/1.

The thermo-optical properties of the finishes are given in the following table:

Surface / Material	Solar Absorptance		Infra-Red
	BOL	EOL	Emittance
Silver Teflon Tape	**0.07**	0.17	**0.65**
Gold Plate / Gold Tape	**0.28**	0.32	**0.04**
Aluminium Kapton Tape (VDA)	**0.12**	0.17	**0.05**
MLI (SSM external)	**0.07**	0.17	**0.65**
Chemical Conversion Coating	**0.47**	0.55	0.14

AMSU-A2 Material Thermo-Optical Properties (TBC)

The radiative environmental temperatures for AMS J-A2 are TBD

3.3.4. Thermal Heat Capacity

The thermal heat capacity of AMSU-A2 is TBD J/K

3.35 Instrument Temperature Measurement

3.3.6. **Thermal Mathematical** Models

AMSU-A2 thermal model exists in SINDA/TRASYS. Conversion to ESATAN/ESABASE is being performed

3.4. THERMAL ENVIRONMENT CONDITIONS

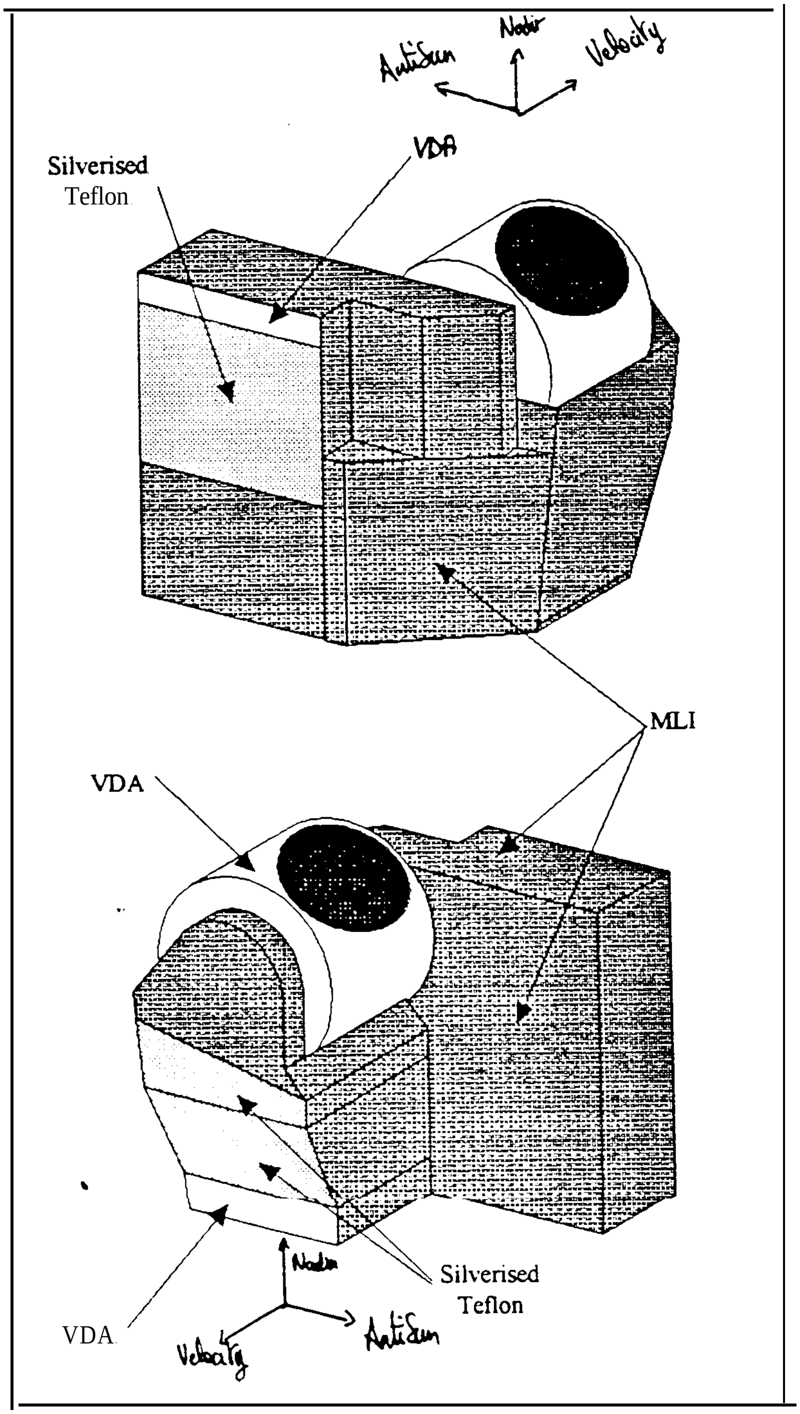


Figure 3.3/1 : AMSU-A2 Thermal Coatings

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Power Sources

AMSU-A2 requires to be power supplied with the following buses :

Power Bus	Number of Interfaces	Goals	TIROS Name
8 V regulated power bus	3	One for the instrument primary power	Main regulated bus
		One for the motors and heaters	Pulse load bus
		One for the temperature sensors when the instrument is off	Switched telemetry bus
0 V regulated power bus	1	One for commands and digital B command verification telemetry	Interface Bus

Voltage range : TBD

Power connection redundancy : TBD

Power **Consumption** and Modes

Basic **Power Consumption**	**LEOP**	**Instr. ON**	**PLM Fix**	**PLM Safe**
+ **28** V regulated power bus :				
Primary power	Off	25.0 W	off	Off
hlotors and heaters	Off	12.0 W	off	Off
Temperature	OffTBC	0.15 W	OffTBC	OffTBC
+ 10 V regulated power bus	OffTBC	0.1 W	OffTBC	OffTBC
TOTAL	0 W TBC	37.25 W	**0 W** TBC	0 W TBC

4.2. COMMAND AND CONTROL INTERFACES

AMSU-A2 synchronously operates with reference to a 1.248 MHz clock (master clock). One 8 sec synchronization signal shall be provided by the platform.

AMSU-A2 requires 4 pulse discrete and 9 level discrete commands from the platform.

1 survival heaters On / Off command.

THIS PAGE WAS
MISSING FROM THE
ORIGINAL DOCUMENT
(NOT SCANNED)

4.3 SCIENCE DATA INTERFACES

16.320 kHz clock

Data enable signal

Digital A data interface

In full scan mode, AMSU-A2 generates 3 16 bytes of measurement data per scan (i.e. during 8 sec.). On TIROS, 14 words in the AIP minor fiame (so for 100 ms) are allocated to AMSU-A2, **and are filled with** 7 pairs of 8-bit words. Hence an apparent raw data rate of 1.120 kbps.

The encapsulation of the 3 16 octets within one source packet result-s in a source packet total length of 330 octets.

The packetized data rate is *then* 0.330 kbps.

4.4. HOUSEKEEPING TELEMETRY

Analog housekeeping telemetry : 11

Digital housekeeping telemetry (digital B) : **10**

Switched telemetry bus thermistor interface : 4

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.52. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCRIPTION

RF Receiver Characteristics

The AMSU-A2 RF receiver has the following specified Characteristics :

CF	BW	Sensitivity
23.80 GHz	270 MHz	-94.8 dBm
31.40 GHz	180 MHz	-96.7 dBm

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

AMSU **includes** a lubricant reservoir for the bearings that is **not sealed and may evaporate (to be clarified).** A class 100 000 room **is** sufficient.

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

None for METOP.

9.1.2. Instrument Engineering Model (EM)

None for METOP.

9.1.3. Instrument Proto-Flight Model (PFM)

None for METOP.

9.1.4. Instrument Flight Model (FM)

2 Flight Models are to be delivered for METOP.

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

The bearing lubricant reservoir needs to be purged on ground with N2 (to be clarified)

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

AMSU-A2 is continuously on along the orbit (duty cycle : 100%)

Commissioning and calibration : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. information Provided by the Platform

Once snitched on, AMSU-A2 nominally proceeds without any requirement for software or parameters update.

1 0S. INSTRUMENT OPERATION MANUAL

Fix and Safe Modes

One command switches the instrument off and internally park the reflectors

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 3 years

Reliability : 0.84 for 3 years

in-Flight Experience : None

12. PROGRAMME AND SCHEDULE

AMSU-A2 is scheduled for a first flight on NOAA-K in 1995

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

MHS

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the MI-IS Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with MHS responses to the generic METOP General instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

The Microwave Humidity Sounder MHS is a five channel self calibrating microwave scanning radiometer. The channels in the frequency **range 89 to 190 GHz provide** a humidity profiling capability. The measured signals are also sensitive to:

- liquid water in clouds and hence can be used to measure cloud liquid water contents
- graupel and large water droplets in precipitating clouds and hence can provide a qualitative estimate of precipitation rate.

MHS channel characteristics are the following :

	Centre Frequency (GHz)	Bandwidth (max.. MHz)	Temperature Sensitivity (K)
H1	89.0	2800	1.00 (goal 0.6)
H2	157.0	2800	1.OO (goal 0.6)
H3	183.311 ± 1.00	2 x 1000 (DSB)	1.00 (goal 0.6)
H4	183.311 ± 3.00	2 x 2000 (DSB)	1.OO (goal 0.6)
H5	190.3 11	2200	1.OO (goal 0.6)

DSB : Dual Side Band

Scan Type :	Continuous
Scan Rate (s) :	2.667
Half Power Antenna Bandwidth (deg.) :	1.1 ± 10 %
Sampling Interval (deg.) :	1.1111 (10/9)
Earth View Pixels per Scan :	90
Scan Angle (deg. with respect to the nadir direction):	± 49.444 deg.
Overall Swath :	± 50 deg.

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94. Iss. 2. dated Sept. 94

Reference Documentation

Unique instrument Interface Specification for the MHS
Ref. IS-20046415 (MET0372). Preliminary Issue
Applicable for US platform only and used for METOP for information

Performance and Functional Specification for the MHS Sounder
Ref. EPS-MI-IS-SPE-93001

MHS Instrument Configuration
Ref. 3 175-JA029-25-1 (MET0567a & b), dated April 1994

MHS Instrument Baseplate Interface Control Drawing
Ref. 3 175-FA002-25-0 (MET0567c), dated April 1994

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

MHS consists of a single unit.

The Part Number and Identification Code of the MHS instrument are :

PART NO: T B D

ID CODE: TBD

The location of the labels giving these Part Numbers and Identification Codes are defined in the Mechanical Interface Control Drawing.

The total envelope is : L (Velocity) x W x H (Earth) 750 x 690 x 560 mm.

MHS does not have any deployable part.

2.1.2. Mechanical Interface Control Drawing

The MHS instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The MHS configuration is illustrated in Figure 2.1/1.

2.1.3. Mass Properties

Mass

The mass properties of the MHS instrument are given in the following table. The co-ordinate system used is the Instrument Mounting Interface Reference Frame. F_{MHS}. with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing. TBD (Cf. drawing). The directions of the F_{MHS} axes are the same as the Spacecraft Reference Frame Fs

Module /Unit	Basic Mass (± 0.1 kg, TBC)	Centre of Mass Location (± 5 mm)		
		X_{MHS} (Sun)	Y_{MHS} (Anti-velocity)	Z_{MHS} (Zenith)
MHS	60.0 kg			

MHS Mass Properties

Moments of **Inertia**

The MHS moments of inertia are as follows. The coordinate system used is the lnstrument Mounting Interface Reference Frame. F_{MHS} (TBC), with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing. TBD (Cf. drawing). The directions of the F_{MHS} axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

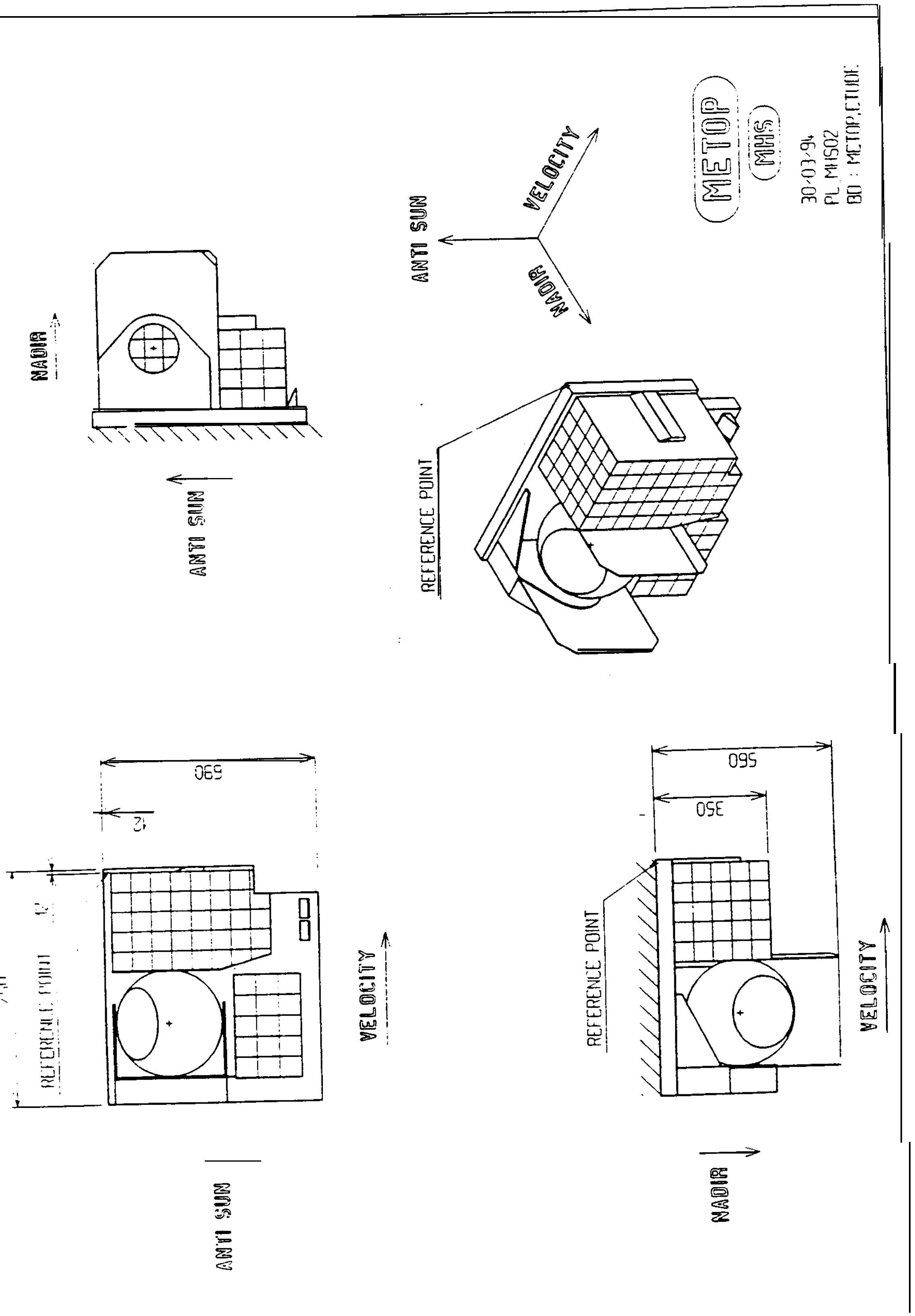


Figure 2.1/1 : MHS Configuration

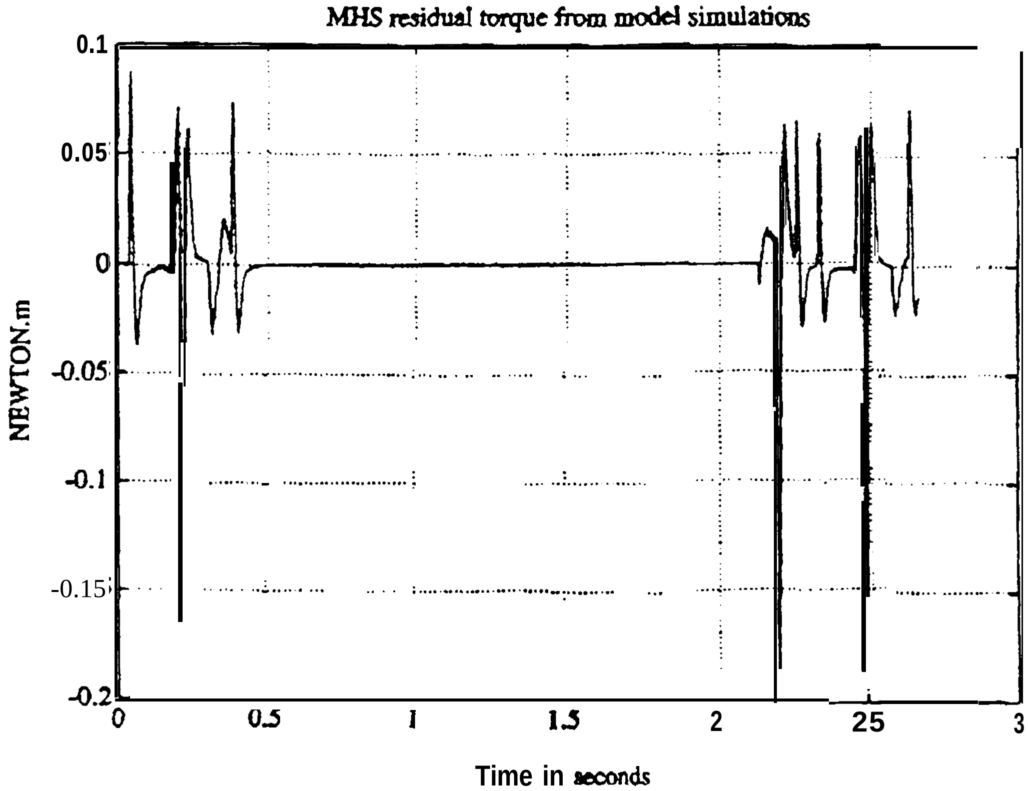


Figure 2.1.4/1 : MHS Residual Torque

2.15 Field of View Definition

MHS boresight is defined as the nadir direction. The instrument field of view definition is :

- one vertex (Cf. drawing)

The beam width is based on a o **220 mm** circle

- Spacecraft provision :

- cross-track scan plane : from 85.0 deg. anti-Sun-war& to 52 deg. Sunwards.

  This is the general envelope for ± 49.5 deg. scanning and + 85 deg. for anti-Sun calibration

- Orbit plane : ± 0 deg (included in the vertex definition)

MHS field of view is illustrated in Figure 2.1.5/1

Module /Unit	Moments of Inertia ($kg.m^2$)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
MHS						

MHS Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

TBD

2.1.4.2. Continuous and Recurring Transient Events

MHS is partially momentum compensated. The typical residual torque over 3 sec. along the Y axis (velocity, scenes are scanned from Sun, through Earth, to space) is illustrated in Figure 2.1.4/1 (from model simulations). The main assumptions are the following :

- Inertia : 10 $g.m^2$ (reflector and shroud)
- Sampling : 432 Hz
- Ripple torque : 13% of torque demand
- Friction : viscous, 0.006 $Nm/rad.s^{-1}$
- Scanning control loop bandwidth : 20 Hz
- Compensation control bandwidth : 20 Hz
- Error on the knowledge of the reflector / shroud inertia : + 3%
- Error on the knowledge of the flywheel : - 3%
- Voltage quantization : 12 bits
- Scanning velocity (during Earth scan) : 60 deg./s

It is assumed that the residual torque on the other axes is negligible.

The static and dynamic unbalance values on each axis are TBD.

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

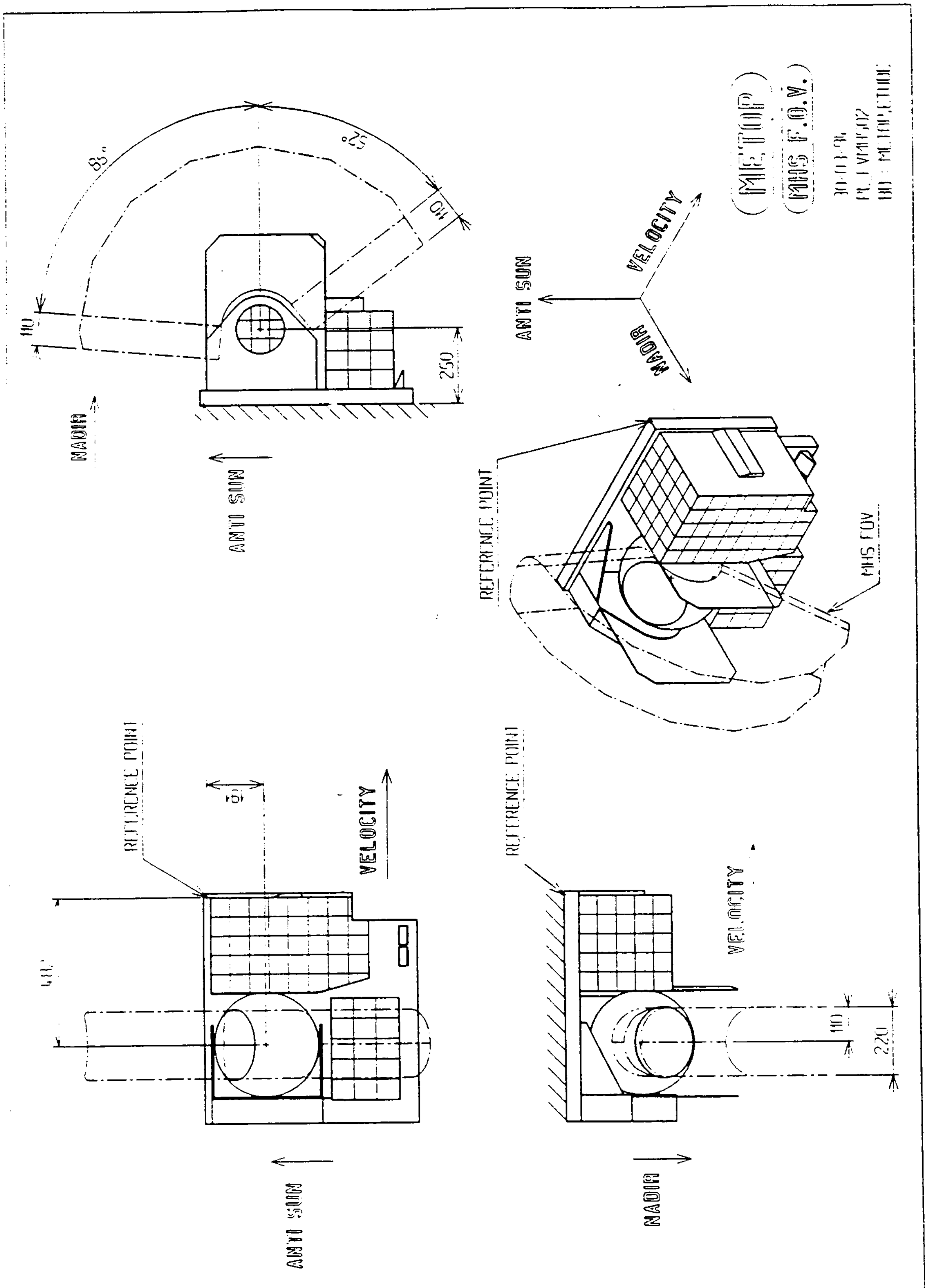


Figure 2.1.5/1 : MHS Field of View

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The MHS instrument is mounted directly to a platform nadir (-Z METOP) panel via iso-metric fine thread titanium bolts, used with GFRP washers (TBC) to provide thermal isolation and passing through instrument flanges, lugs or structural components which mate with the platform interface.

The bolt size, length and torque required to mount the instrument are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
MHS				

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for the MHS instrument is given in the Mechanical Interface Control Drawing, TBD (Cf. drawing).

2.2.3. Mounting Surfaces

MHS is mounted on its +Z (METOP axis) side. The flatness of the mounting surfaces does not exceed 0.1 mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of TBD mm^2.

2.2.4. Materials

The material of the MHS baseplate and the interfacing platform panel is CFRP.

2.2.5. Interface Loads

The calculated interface loads induced by the MHS instrument are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
MHS Baseplate				

2.2.6. Accessibility

There is no specific accessibility requirement for MHS.

2.2.7. Grounding Point

The locations of the grounding points on the MHS instrument are defined in TBD.

2.3. POINTING

The pointing requirements for the MHS instrument are expressed at the Instrument Mounting Interface Reference Frame F_{MHS}.

Absolute Pointing Error (Accuracy) :	± 0.15 deg. (3σ)
Absolute Measurement Error (Knowledge) :	± 0.10 deg. (3σ)
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical Interface Control Drawing, TBD. The cube has two alignment surfaces of size 25 x 25 mm^2 which are viewed from the spacecraft nadir (-Z), anti-Sun (-X) and anti-velocity (+Y) axes and meet the requirements specified in the GICD (TBC).

The cube shall be covered with a cover/removed in accordance with TBD prior to launch.

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

The co-alignment requirements are expressed between the Instrument Mounting Interface Reference Frames (F_{MI}) of each instrument.

MHS shall be co-aligned with AVHRR/3 to within ± 0.05 deg. (3σ).

Note that the following information can be found in the UIIS (Cf. § 1.3.) :

- Co-alignment Requirements : ± 0.30 deg. (3σ) with respect to AMSU-A1
  ± 0.36 deg. (3σ) with respect to AMSU-A2

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD.

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequency of the MHS instrument is 108 Hz (without margin, PDR status, the specification is 100 Hz), this value having been established by analysis.

As this frequency is above the 100 Hz limit, no mechanical interface model is required.

2.6. MECHANISMS

2.6.1. Functional Description

A scan mechanism consisting of two motors with their associated drive electronics, supports a single reflector assembly and performs scanning of the instrument field of view across the Earth, an on-board hot calibration target and cold space for calibration, every 2.67 seconds. One of the motor drives a compensating fly-wheel providing momentum compensation to limit the perturbation induced on the platform by the scan motion.

2.6.2. Performances

2.7. PYROS

None.

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

None

2.8.2. Removable Covers (Non-Flight Items)

Reflector / shroud cover : TBD.

2.8.3. Deployable Covers (Flight Items)

None

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1 Category

MHS is a Category A instrument. Its thermal control is autonomous with dedicated radiators on the instrument sides.

3.1.2. Thermal Control Philosophy

Normal Operation

During nominal operating modes, MHS uses passive radiators to reject its heat to space.

Contingency Modes

During the contingency modes the instrument is switched off, and internal heaters are required to supply make-up heat. The temperature of MHS will be maintained within its survival limits by these heaters which are controlled using thermostats with a lower set point of -10 deg. C.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the MHS instrument are defined below. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C	Operation		Non-Operation		Switch-On
MHS	Min.	Max.	Min.	Max.	Min.
Acceptance	-5	+30	-20	+40	-10
Qualification (TBC)	-10	+35	-25	+45	-15

Stability Requirements

There is no stability requirement for MHS.

3.2.2. Radiative Interface

The MHS passive radiator areas and the thermal views to space are given below :

3.2.6. Thermo-Elastic Interface

The MHS instrument has an CFRP baseplate with a coefficient of thermal expansion of 2.0×10^{-6} / deg. C (TBC). The PLM mounting panel is aluminium honeycomb with CFRP skins with a coefficient of thermal expansion of 2.0×10^{-6} / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interface is the instrument baseplate which is defined in the Mechanical Interface Control Drawing (TBD), and in § 2.2.3.

The total thermal conductance between the MHS instrument and the platform is TBD W/K.

The calculated temperatures at the MHS conductive interfaces are TBD.

3.3.3. Radiative Interfaces

The external surfaces of the MHS instrument, and the finishes used are given in the Thermal Interface Drawing (TBD). The MHS thermal coatings are illustrated in Figure 3.3/1.

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red Emittance
	BOL	EOL	
SSM	0.09	0.18	0.79
White Paint	0.19	0.55	0.88
MLI (Kapton / VDA)	0.39	0.59	0.62

MHS Material Thermo-Optical Properties

The radiative environmental temperatures for MHS are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacity of MHS is TBD J/K.

3.3.5. Instrument Temperature Measurement

3 survival thermistors, directly read by the platform.

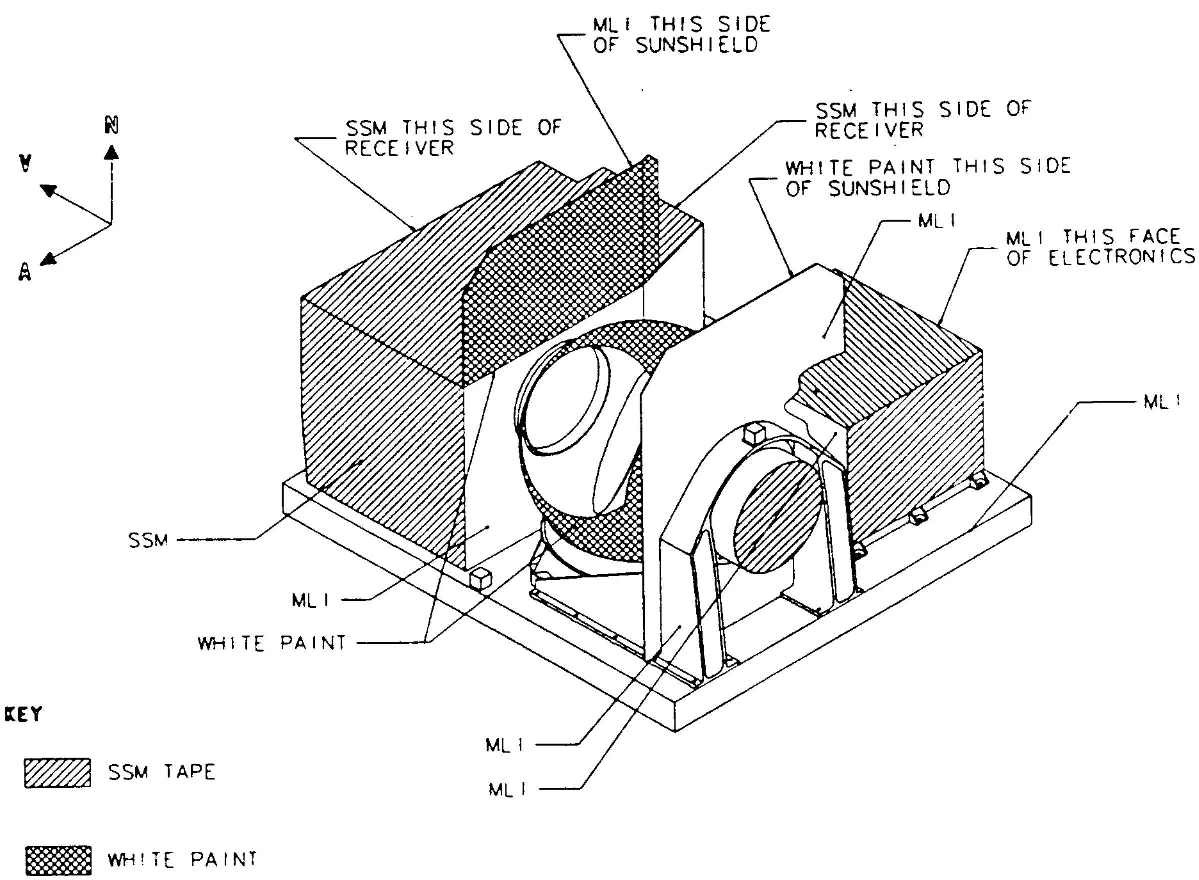


Figure 3.3/1 : MHS Thermal Coatings

3.3.6. Thermal Mathematical Models

A reduced thermal mathematical model in ESATAN (V5.5 or higher) including thermal case description, geometrical model and node description, is to be delivered.

3.4. THERMAL ENVIRONMENT CONDITIONS

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

MHS input voltage is either 22-37 Volts DC unregulated or +28 V regulated (measured at MHS terminals). METOP uses unregulated power buses.

The following power buses are provided by the platform :
- equipment power bus, nominal and redundant
- equipment heater power bus, nominal and redundant (for non-operating modes)
- ICU (Instrument Control Unit) power bus, nominal and redundant
- ICU heater power bus, nominal and redundant (for non-operating modes)

The total power consumption is 90 W in nominal operations (basic value).

4.2. COMMAND AND CONTROL INTERFACES

The command and control of the instrument is performed via the PLM OBDH bus. MHS ICU has a nominal and redundant connection to the OBDH via a DBU supplied by the platform.

In case of emergency, MHS can receive the following signals :
- equipment switch off line (EQU SOL), nominal and redundant
- depointing signal line (DSL), nominal and redundant

4.3 SCIENCE DATA INTERFACES

MHS generates packetized measurement data, that are transferred to the PLM data handling subsystem via a nominal and redundant connection through low bit rate data interface.

MHS generates 1280-octet length science data source packet per scan (i.e. for 2.667 sec.). The packetized data rate is then 3.840 kbps.

4.4. HOUSEKEEPING TELEMETRY

Thermistor interface :
- thermistor for equipment, nominal and redundant connection to the platform
- thermistor for ICU, nominal and redundant connection to the platform

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCRIPTION

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

No acoustic test is foreseen by MHS verification plan.

7.2.4. Thermal Test Description

The MHS FM unit will go through 4 thermal vacuum cycle test.

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

9.1.2. Instrument Engineering Model (EM)

9.1.3. Instrument Proto-Flight Model (PFM)

9.1.4. Instrument Flight Model (FM)

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

MHS is continuously on along the orbit (duty cycle : 100%).

Commissioning and calibration : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

Once switched on, MHS nominally proceeds without any requirement for software or parameters update.

10.5. INSTRUMENT OPERATION MANUAL

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime :	5 years
Reliability :	0.8 over 4 years (specification)

12. PROGRAMME AND SCHEDULE

System Concept Review (SCR)	May 1994
Preliminary Design Review (PDR)	September 1994
Critical Design Review (CDR)	March 1996
PFM delivery	July 1997
FM2, FM3 and FM4 (spare) deliveries	February 1998, September 1998 and April 1999

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

DCS/2

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the DCS/2 Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with DCS/2 responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

The Data Collection System DCS, known also as ARGOS, collects data from platform transmitters (PTTs) located on continents and oceans in VHF frequency. Marine PTTs located on buoys transmit oceanographic data, ship PTTs weather and oceanographic data ; land based PTTs provide meteorological and hydrological data and those on balloons atmospheric data. DCS uses Doppler information to enable the location of PTTs. The data are stored on board the satellite for later transmission to ground. The DCS system consists of :

- a Receiving and Power Unit RPU
  - UHF receiver
  - Detection Unit (FFT)
  - Control Unit
  - Power and Control Unit
- a Signal Processing Unit SPU
  - 2 x 4 Data Receiver Units (DRU)
- one VHF receive antenna UDA

The performance characteristics are the following :

Receive Frequency :	401.65 ±0.04 MHz
Receiver Bandwidth (1 dB) :	80 kHz
MDS :	-108 to -131 dBm
Frequency Stability :	2E-9 over TBD sec.
Receive antenna (UDA) :	quadrifilar helix antenna
Max. gain:	+ 6 dBi at 60 deg. off nadir
	-3 dBi at nadir

The UDA antenna has a pattern as illustrated in Figure 1.2/1.

A Data Collection Platform command down link (460-470 MHz) from SPU (DRU) through UDA is under consideration.

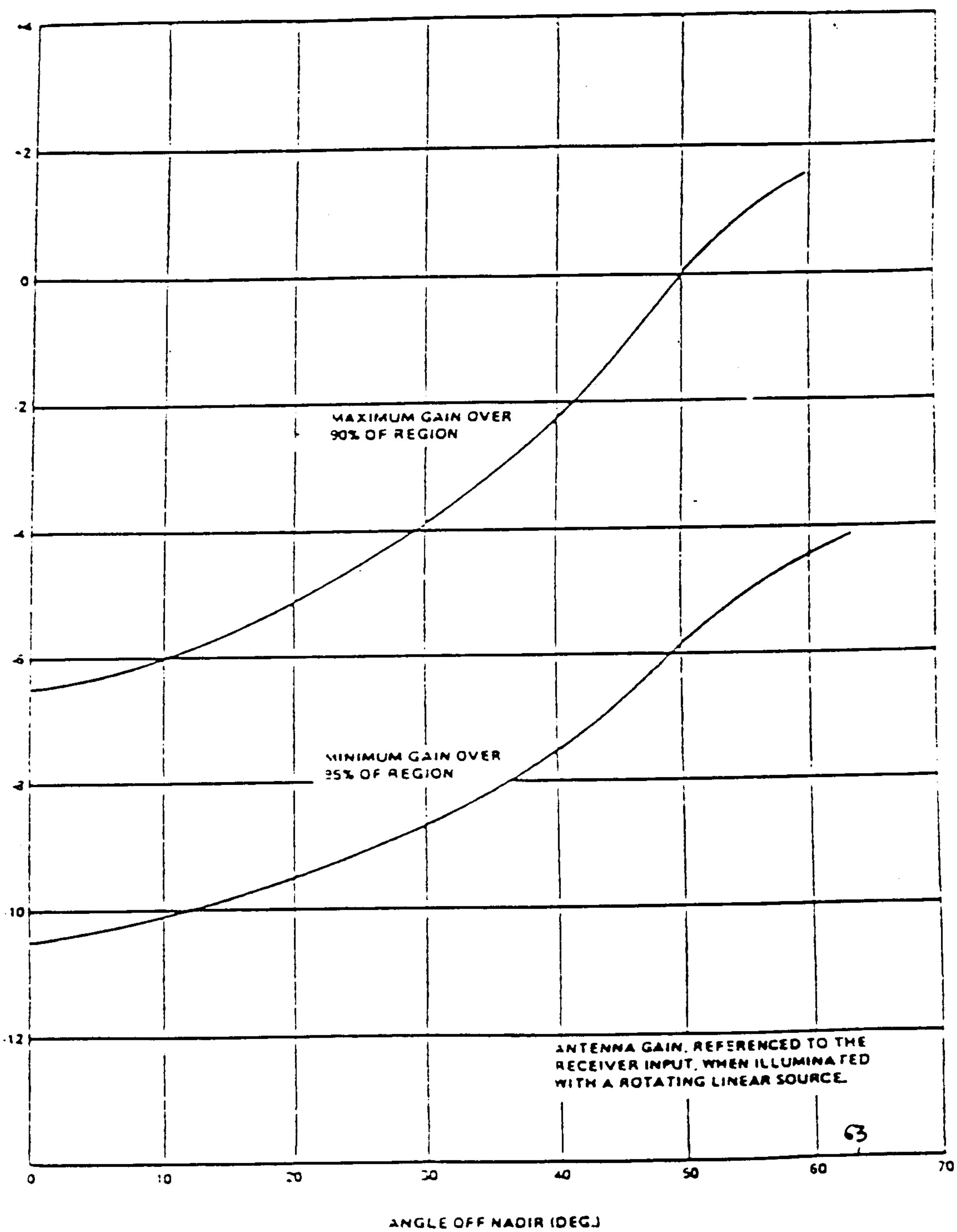


Figure 1.2/1 : DCS UDA Antenna Pattern

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94, Iss. 2, dated Sept. 94

Reference Documentation

Unique Interface Specification for DCS-2
Ref. IS-3267402 (MET0030), dated July 1992, rev. A

DCS-2 RPU Interface Control Drawing
Ref. 8212-200E380 (MET0015), dated December 1990

DCS-2 SPU Interface Control Drawing
Ref. 8212-300E380 (MET0016), dated December 1990

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

DCS-2 is composed of three separate electronics units, that are linked with an antenna (UDA) that is part of the platform. The 3 electronic units have the following part numbers and identification codes :

Module / Unit	Acronym	Part No	ID Code
Receiving and Power Unit	RPU		
Signal Processing Unit -A	SPU-A		
Signal Processing Unit -B	SPU-B		

All three units are mounted on a radiator panel within the METOP Service Module (SVM) (TBC).

The overall dimensions of the units are :

Module / Unit	L (Velocity)	W	H (Earth)
RPU	195 mm	365 mm	280 mm
SPU-A	195 mm	310 mm	280 mm
SPU-B	195 mm	310 mm	280 mm

The UDA antenna, diplexers and filters are provided by the platform.

There is a requirement that the total insertion loss is less than 2 dB between the UDA and the DCS/2 units. To meet this requirement, it has been assumed that the RPU shall be within 2 metre distance from the UDA.

2.1.2. Mechanical Interface Control Drawing

The DCS/2 instrument unit configuration and mechanical interfaces are given in the Mechanical Interface Control Drawings, TBD.

2.1.3. Mass Properties

Mass

The mass properties of the DCS/2 units are given in the following table. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each unit, F_{DCS-i} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the F_{DCS-i} axes are the same as the Spacecraft Reference Frame Fs.

The antenna, UHF devices and the related harness masses shall be accounted for in the platform budgets.

Module /Unit	Basic Mass (± 0.1 kg, TBC)	Centre of Mass Location (± 5 mm)		
		X_{DCS-i} (Sun)	Y_{DCS-i} (Anti-velocity)	Z_{DCS-i} (Zenith)
RPU	13.8 kg			
SPU-A	12.6 kg			
SPU-B	12.6 kg			
TOTAL :	39.0 kg			

DCS/2 Mass Properties

Moments of Inertia

The DCS/2 moments of inertia are given in the following table. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each unit, F_{DCS-i} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the F_{DCS-i} axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

Module /Unit	Moments of Inertia (kg.m^2)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
RPU						
SPU-A						
SPU-B						

DCS/2 Moments of Inertia

2.1.4. Instrument Induced Disturbances

None

2.1.5. Field of View Definition

None (the spacecraft will however provide antenna clear field of view).

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The DCS/2 units are mounted to the SVM panel (TBC) using bolts.

The bolt size, length and torque required to mount the units are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
RPU				12
SPU-A				
SPU-B				

2.2.2. Reference Point (Hole)

The definitions of the Reference Points / Holes for the DCS/2 units are given in the Mechanical Interface Control Drawings, TBD.

2.2.3. Mounting Surfaces

The mounting surfaces for the DCS/2 units are the unit baseplates (W x H). The three units can be accommodated in any direction. The flatness of the mounting surfaces does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of TBD mm^2.

2.2.4. Materials

The material of the DCS/2 baseplates is aluminium alloy with a TBD finish. The SVM mounting interface is an aluminium honeycomb panel with aluminium facing skins.

2.2.5. Interface Loads

The calculated interface loads induced by the DCS/2 units are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
RPU				
SPU-A				
SPU-B				

2.2.6. Accessibility

Connectors : TBD.

2.2.7. Grounding Point

The locations of the grounding points on the DCS/2 units are defined in TBD.

2.3. POINTING

None (antenna pointing is a platform issue)

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Loads

2.5.3. Safety Factors

The calculated safety factors are TBD.

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequencies of the DCS/2 instrument units are above 350 Hz.

As this frequency is above the 100 Hz limit, no mechanical interface model is required.

2.6. MECHANISMS

DCS-2 contains no movable mechanism.

2.7. PYROS

None.

2.8. INSTRUMENT APERTURE COVERS

None

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

The RPU, SPU-A and SPU-B units are all Category B units (collectively controlled).

3.1.2. Thermal Control Philosophy

The internal thermal design of the units is such that the majority of the unit dissipation is conducted to the unit baseplates. Thermal interface filler is used to ensure good thermal conductance between the unit baseplates and the radiator panels on which the units are mounted.

The exterior of the units is black painted to facilitate some heat loss by radiation to the interior of the platform (Service Module).

The temperature of the units is controlled by the SVM (TBC) thermal control subsystem.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the DCS/2 units are defined in Tables 3.2/1 and 3.2/2. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C DCS/2	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
RPU	-5	+45	-30	+60	-10
SPU-A	-5	+45	-30	+60	-10
SPU-B	-5	+45	-30	+60	-10

Table 3.2/1 : DCS/2 Unit Acceptance Temperatures

Deg. C DCS/2	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
RPU	-10	+50	-35	+65	-15
SPU-A	-10	+50	-35	+65	-15
SPU-B	-10	+50	-35	+65	-15

Table 3.2/1 : DCS/2 Unit Qualification Temperatures (TBC)

Stability Requirements

There is no temperature stability requirement for the DCS/2 units.

3.2.2. Radiative Interfaces

The sides of the units are black painted to facilitate radiation exchange with the platform interior.

3.2.3. Heater Power Budgets

None.

3.2.4. Instrument Thermal Dissipation

The total thermal dissipation of the DCS/2 units is 30.2 W. The individual unit thermal dissipations are TBD. The redundancy scheme, if any, between SPU-A and SPU-B shall be specified.

The dissipations of the DCS/2 units are constant throughout the orbit and are :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
RPU				
SPU-A				
SPU-B				

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the DCS/2 units for different cases are :

Module / Unit	Operative Heat Transfer (Orbit Average, Watts)			
	Conductive Hot Case	Conductive Cold Case	Radiative Hot Case	Radiative Cold Case
RPU	TBD	TBD	TBD	TBD
SPU-A	TBD	TBD	TBD	TBD
SPU-B	TBD	TBD	TBD	TBD

3.2.6. Thermo-Elastic Interface

The DCS/2 units baseplates have an aluminium baseplate with a coefficient of thermal expansion of 25 x 10^{-6} / deg. C (TBC). The SVM interfacing structure for all the units is aluminium honeycomb or doublers with a coefficient of thermal expansion of 25.0 x 10^{-6} / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interfaces for the DCS/2 units are defined in the Mechanical Interface Control Drawing (TBD) and in § 2.2.3. A thermal interface filler will be used between the units and the SVM panel. The contact areas of the DCS/2 units are :

- RPU TBD mm^2
- SPU-A TBD mm^2
- SPU-B TBD mm^2

The calculated temperatures at the DCS/2 units conductive interfaces are TBD.

3.3.3. Radiative Interfaces

The external surfaces of the DCS/2 units is black paint with an emittance of 0.9 (TBC). The interior of the SVM is also black painted with the exception of the black CFRP central cone.

The radiative environmental temperatures for the DCS/2 units are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacities of the DCS/2 units are TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

3.4. THERMAL ENVIRONMENT CONDITIONS

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Power Sources

DCS/2 requires to be power supplied with the following buses :

Power Bus	Number of Interfaces	Goals	TIROS Name
+ 28 V regulated power bus	2	One for the instrument primary power One for the temperature sensors when the instrument is off	Main regulated bus Switched telemetry bus
+ 10 V regulated power bus	1	One for commands and digital B command verification telemetry	Interface Bus

Voltage range : TBD

Power connection redundancy : TBD

Power Consumption and Modes

RPU basic power : TBD
SPU-A basic power : TBD
SPU-B basic power : TBD

(TOTAL : 27,445 W, Instrument ON)

4.2. COMMAND AND CONTROL INTERFACES

No synchronization clock. Synchronization signal : a major frame synchronization pulse, every 32 sec.

Pulse discrete commands : 24 (no level discrete command)

4.3 SCIENCE DATA INTERFACES

8.320 kHz clock
Data enable signal
Digital A data interface

On TIROS, DCS/2 generates 32 8-bit TIP words for 100 ms, hence an apparent raw data rate of 2.560 kbps.

However, DCS-2 message length varies from 16 to 44 words upon the number of sensors (one to eight) contained in the platform transmission (note that one sensor requires four words).

With no complementary information, a data rate of 2.560 kbps is considered.

4.4. HOUSEKEEPING TELEMETRY

Analog housekeeping telemetry :	9
Digital housekeeping telemetry (digital B) :	15
Switched telemetry bus thermistor interface :	4

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCRIPTION

Conducted Susceptibility Through Antenna

Below are specified the unwanted signals coming by conduction from the antenna to the receiver input.

The following values are :

- the maximum level for any emission generated by the spacecraft ;
- the maximum level of emission the instrument can withstand.

Level at the receiver input (dBm)	Frequency (MHz)
0	1 - 15
-20	15 - 375
-60	375 - 385
-100	385 - 396
-125	396 - 401.570
-150	401.570 - 401.730
-125	401.730 - 406
-100	406 - 411
-60	411 - 425
-20	425 - 1000
-17	1000 - 10000

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.3.1. Quasi-Static Test

7.2.3.2. Dynamic Model Validation

7.2.3.3. Vibration Tests

Sinus

DCS goes trough high level sinus which levels are :

NOAA Qualification levels :

In the thrust direction, 10 g up to 60 Hz and 3 g from 60 to 2000 Hz.

In the two lateral directions, 6 g up to 60 Hz and 2.5 g from 60 to 2000 Hz.

Those values are below the profile requested by METOP. The levels should be increased for qualification to (Cf. GICD) :

5 to 18 Hz	±11 mm
18 to 60 Hz	±15 g
60 to 100 Hz	±6 g
Duration 2 Oct/min	

Random Vibrations

Status on NOAA levels

The Random levels for DCS/2 are :

Qualification Levels

Axis perpendicular to mounting plane			Horizontal axes 1 & 2 (in the mounting plane)		
Frequency Range (Hz)	Power Spectral Density g^2/Hz	Slope (dB/Oct.)	Frequency Range (Hz)	Power Spectral Density g^2/Hz	Slope (dB/Oct.)
20 to 75	0.025		20 to 75	0.011	
75 to 150		+10	75 to 150		+10
150 to 500	0.25		150 to 500	0.11	
500 to 2000		-7	500 to 2000		-7
Overall level 13.3 g rms	Duration 1 min per axis		Overall level 8.8 g rms	Duration 1 min per axis	

Acceptance Levels

Axis perpendicular to mounting plane			Horizontal axes 1 & 2 (in the mounting plane)		
Frequency Range (Hz)	Power Spectral Density g^2/Hz	Slope (dB/Oct.)	Frequency Range (Hz)	Power Spectral Density g^2/Hz	Slope (dB/Oct.)
20 to 75	0.011		20 to 75	0.005	
75 to 150		+10	75 to 150		+10
150 to 500	0.11		150 to 500	0.05	
500 to 2000		-7	500 to 2000		-7
Overall level 8.8 g rms	Duration 1 min per axis		Overall level 5.9 g rms	Duration 1 min per axis	

METOP Required Levels

The application of the METOP GICD levels produces for DCS units of 12/14 kg the following levels :

Qualification Levels

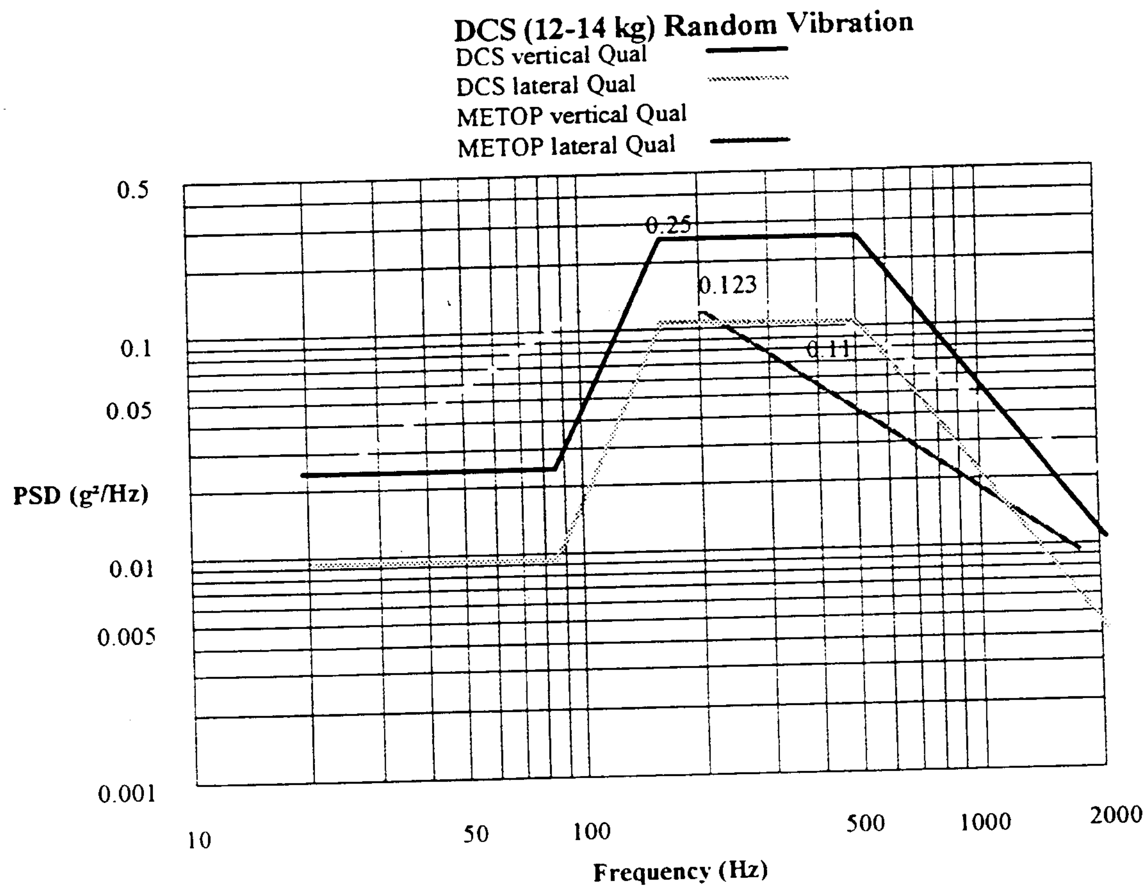
Perpendicular to mounting plane

Frequency (Hz)	20 to 100	100 to 400	400 to 2000
Power Density	+3 dB/Oct	0.123 g^2/Hz	-3 dB/Oct.

Two axes parallel to mounting plane

Frequency (Hz)	20 to 100	100 to 200	200 to 2000
Power Density	+3 dB/Oct	0.123 g^2/Hz	-3 dB/Oct.

The comparison can be seen in the figure below:



The qualification values requested by METOP are well below the request by NOAA both for vertical and lateral directions. Just in the low frequency range below 100 Hz, NOAA asks for lower values. These range has little energy and it applies at a frequency that is well below the first natural frequency of the instrument; so its impact on the instrument will be small.

Then the NOAA requested random test levels of DCS are acceptable for METOP.

7.2.3.4. Acoustic Test

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

None for METOP.

9.1.2. Instrument Engineering Model (EM)

None for METOP.

9.1.3. Instrument Proto-Flight Model (PFM)

None for METOP.

9.1.4. Instrument Flight Model (FM)

2 Flight Models are to be delivered for METOP.

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

DCS/2 is continuously on along the orbit (duty cycle : 100%).

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

Once switched on, DCS/2 nominally proceeds without any requirement for software or parameters update.

10.5. INSTRUMENT OPERATION MANUAL

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 3 years

Reliability : TBD

Flight Experience : More than 5 years

12. PROGRAMME AND SCHEDULE

DCS/2 is scheduled for a first flight on NOAA-K in 1995.

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

IASI

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the IASI Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with IASI responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

IASI stands for Infrared Atmospheric Sounder Interferometer.

IASI is an infrared Fourier transform spectrometer performing a night and day passive remote sensing of the atmosphere within 3.5 to 15.5 μm range. IASI includes an "integrated imaging system" which allows characterization of cloudiness inside the IFOV. The total field of view is ± 49 deg. from nadir.

Measurements on cold reference targets (two views to the space are accommodated) and hot reference target (on-board black body) are taken every 8 seconds for the updating of calibration tables.

IASI transmits to the Earth calibrated spectrum of the atmospheric column with :
- a 25 km sampling distance at sub satellite point ;
- a 0.25 cm^{-1} unapodized spectral resolution (0.01 cm^{-1} absolute accuracy) ;
- a 1 K absolute radiometric accuracy.

IASI has 2 x 2 matrix of IFOV sampled at each mirror position (30 mirror positions in Earth view).

IFOV (deg.) : 1.25 (circular)
Sampling Interval (deg.) : 3.3
Earth View Pixels per Scan : 30
Swath (deg. with respect to the nadir direction) : ± 48.675 deg.
IASI IFOV shall be co-registrated with AMSU ones (TBC).

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94, Iss. 2, dated Sept. 94

Reference Documentation

IASI Instrument Data List
Ref. IA-TN-1.0-61-IPT (MET0034), dated June 1993, Iss. 1

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

IASI is composed of three separated modules with the following part numbers and identification codes :

Module / Unit	Acronym	Part No	ID Code
Sensor Module	-		
Main Electronics Module	MEM		
Secondary Electronics Module	SEM		

The Sensor Module and SEM are located on the anti-Sun floor of the spacecraft and the MEM is located inside the PLM. The Sensor Module has a deployable cover which is deployed in orbit. The maximum distance allowed between both electronic modules is 2 metres (TBC).

The overall dimensions of the units are :

Module / Unit	L (Velocity)	W	H (Earth)
Sensor Module - Stowed			
Sensor Module - Deployed	928 mm	1443 mm	798 mm
MEM	490 mm	655 mm	260 mm
SEM	600 mm	500 mm	350 mm

These dimensions include MLI blankets.

The harness between the IASI units will be supplied by the Instrument (TBC).

2.1.2. Mechanical Interface Control Drawing

The IASI instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The IASI sensor module deployed configuration is illustrated in Figure 2.1/1.

2.1.3. Mass Properties

Mass

The mass properties of the IASI instrument are given in Table 2.1/1. The mass values are with a 20% contingency. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each module, F_{IASI-i} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing for the sensor module). The directions of the F_{IASI-i} axes are the same as the Spacecraft Reference Frame Fs.

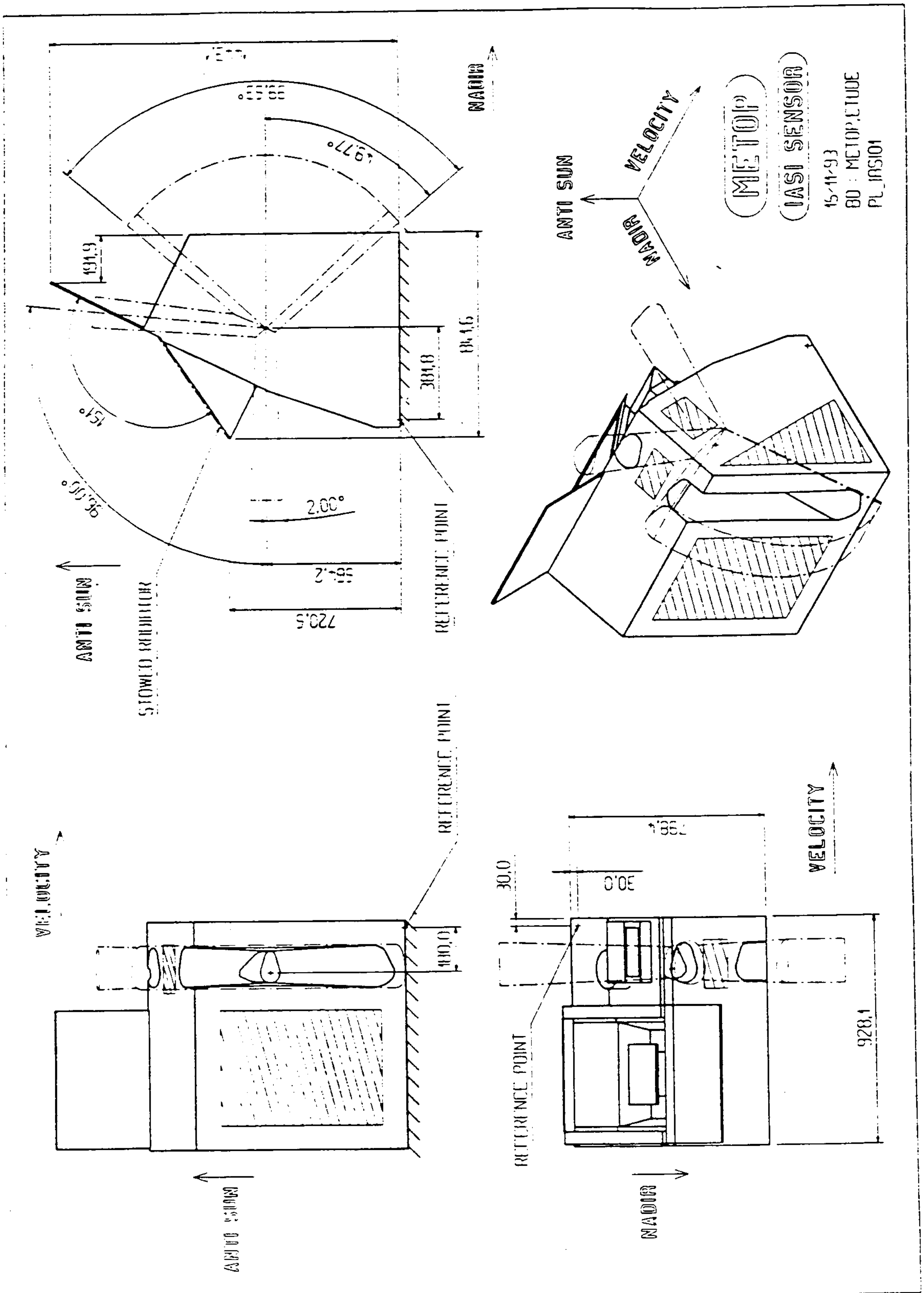


Figure 2.1/1 : IASI Sensor Configuration and Field of View

Module /Unit	Current Mass (± 0.1 kg, TBC)	Centre of Mass Location (± 5 mm)		
		X_{IASI-i} (Sun)	Y_{IASI-i} (Anti-velocity)	Z_{IASI-i} (Zenith)
Sensor Module - Stowed	99.8 kg	- 518 mm	+ 429 mm	- 383 mm
Sensor Module - Deployed	99.8 kg	TBD	TBD	TBD
MEM	27.3 kg	327.5 mm	245 mm	130 mm
SEM	20.5 kg	250 mm	300 mm	175 mm
TOTAL :	147.6 kg			

Table 2.1/1 : IASI Mass Properties

Moments of Inertia

The IASI moments of inertia are given in Table 2.1/2. The mass values are with a 20% contingency. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each module, F_{IASI-i} (TBC), with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD (Cf. drawing for the sensor module). The directions of the F_{IASI-i} axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

Module /Unit	Moments of Inertia (kg.m²)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
Sensor Module - Stowed	TBD	TBD	TBD	TBD	TBD	TBD
Sensor Module - Deployed	9.75	12.6	17.2	- 0.8	0.2	- 0.2
MEM	0.53	0.86	1.2	0.0	0.0	0.0
SEM	0.86	0.67	1.1	0.0	0.0	0.0

Table 2.1/2 : IASI Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

Cooler Door Opening : TBD

2.1.4.2. Continuous and Recurring Transient Events

Motion of the scanning mirror

Time measurement simulation outputs are illustrated in Figure 2.1/2 for the torque profile on the Y axis (scenes are scanned from Sun, through Earth, to space) over a period of 8 sec. The static and dynamic unbalance values on each axis are TBD.

Motion of one of the two cube corners (interferometer)

The definition of the displacements is illustrated in Figure 2.1/3. The disturbance force is illustrated in Figure 2.1/4, by a FFT sampled at 0.1 Hz.

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

2.1.5. Field of View Definition

IASI boresight is defined as the nadir direction. The instrument field of view definition is :

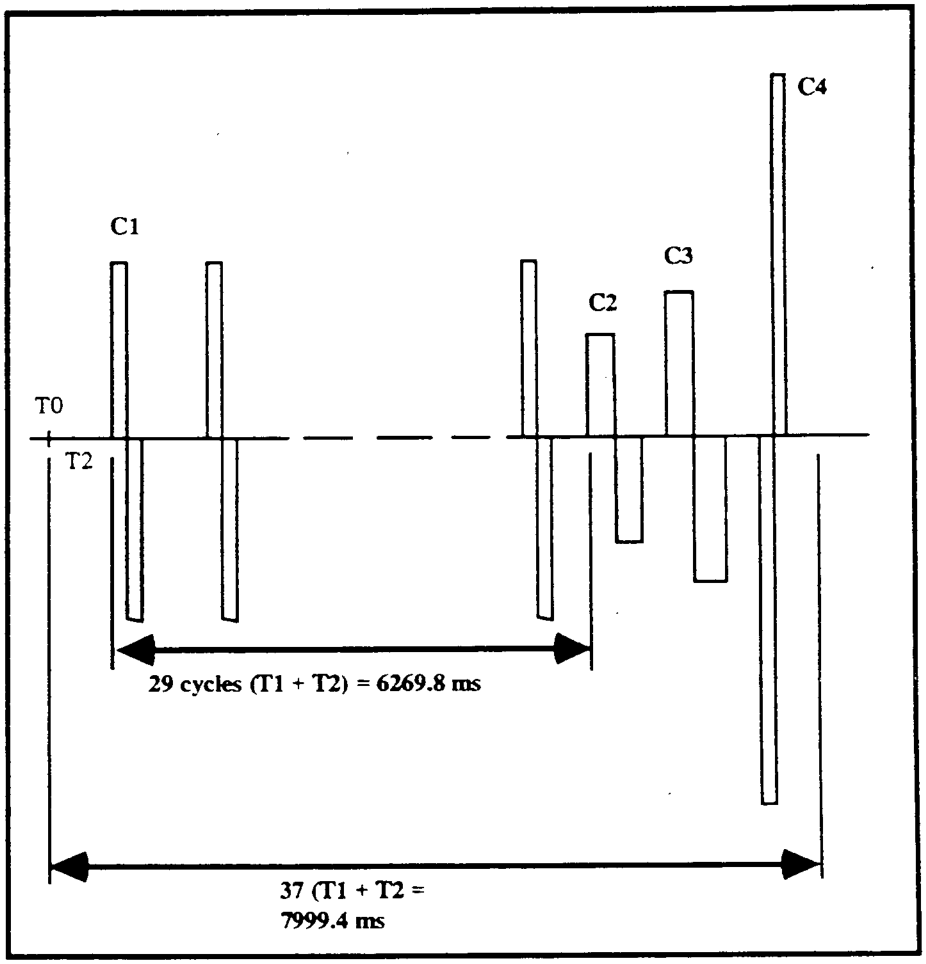
- Vertex : Cf. drawing
- The spacecraft allocation is ± 49.5 deg.

Calibration field of view to deep space

- first sight at 84 ° from nadir
- second sight at 0 ° anti nadir.

IASI fields of view are illustrated in Figure 2.1/1.

IASI torque scanning cycle can be represented in the following way :

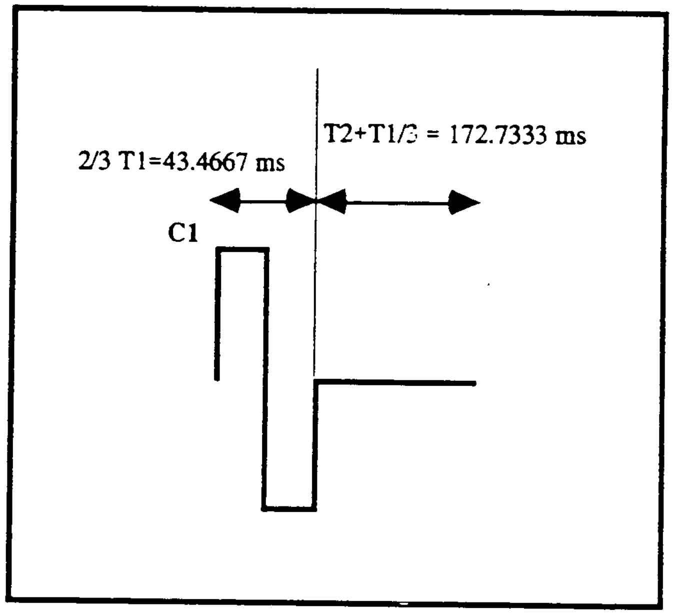


With C1 = 0.0469 Nm
C2 = 0.0283 Nm
C3 = 0.0496 Nm
C4 = 0.1500 Nm

T1 = 65.2 ms
T2 = 151 ms

Figure 2.1/2 : IASI Scanning Torque Profile (1/3)

1- 29 scanning cycles of 1.65°



2- 1 scanning of 18.575 °

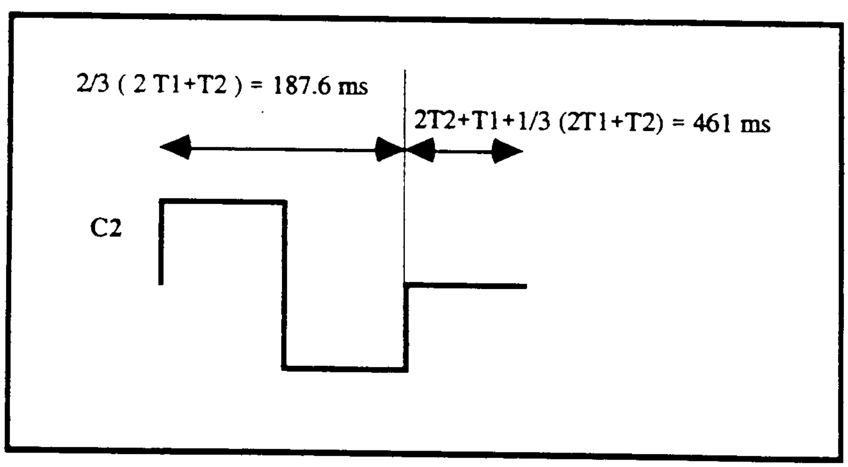
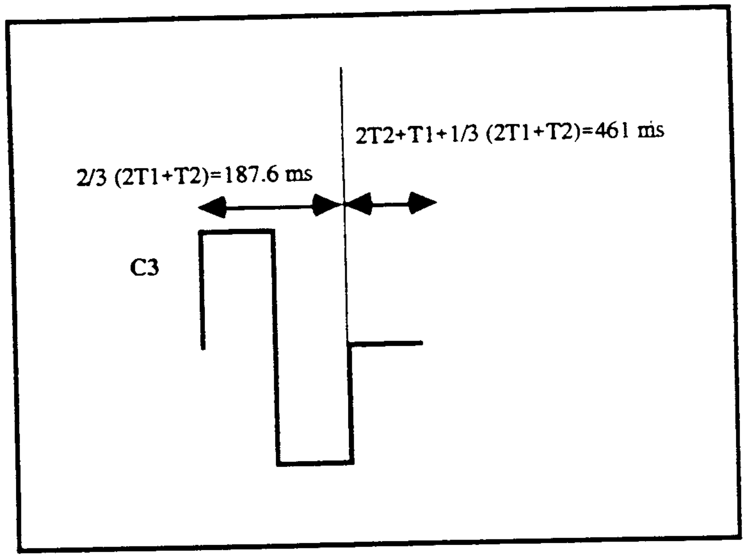


Figure 2.1/2 : IASI Scanning Torque Profile (2/3)

3- 1 scanning of 32.5 °



4- 1 scanning of 98.925 ° :

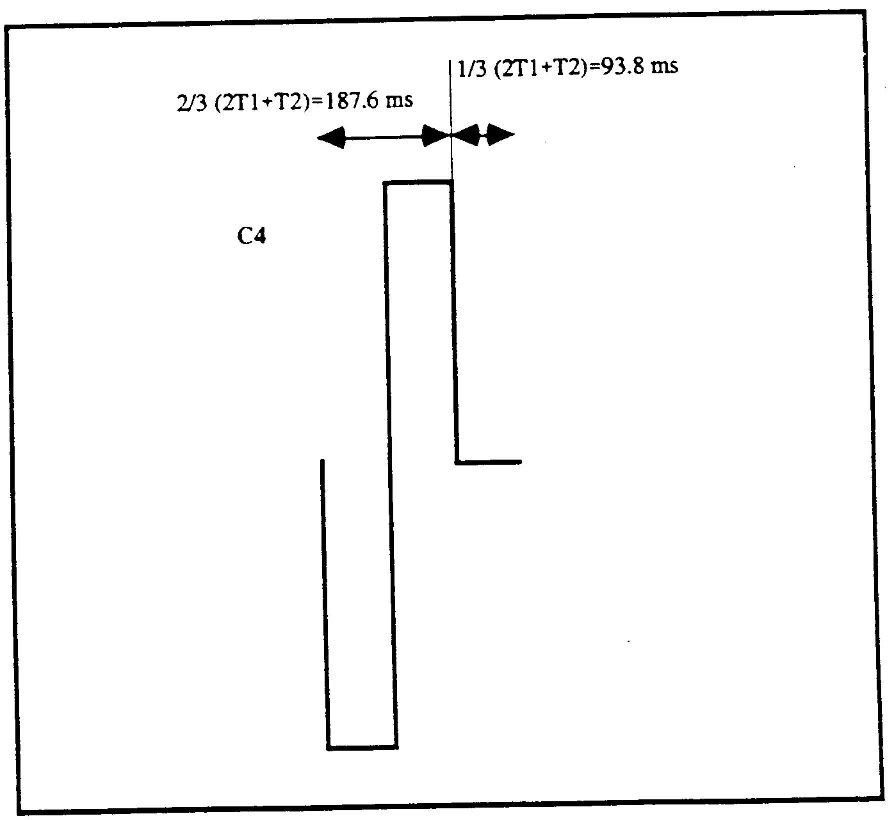
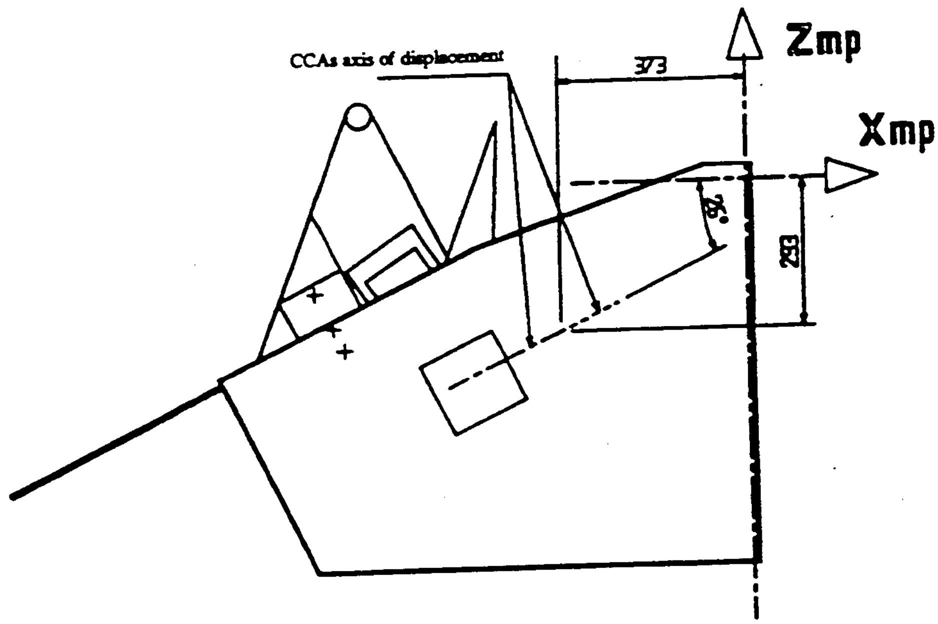


Figure 2.1/2 : IASI Scanning Torque Profile (3/3)



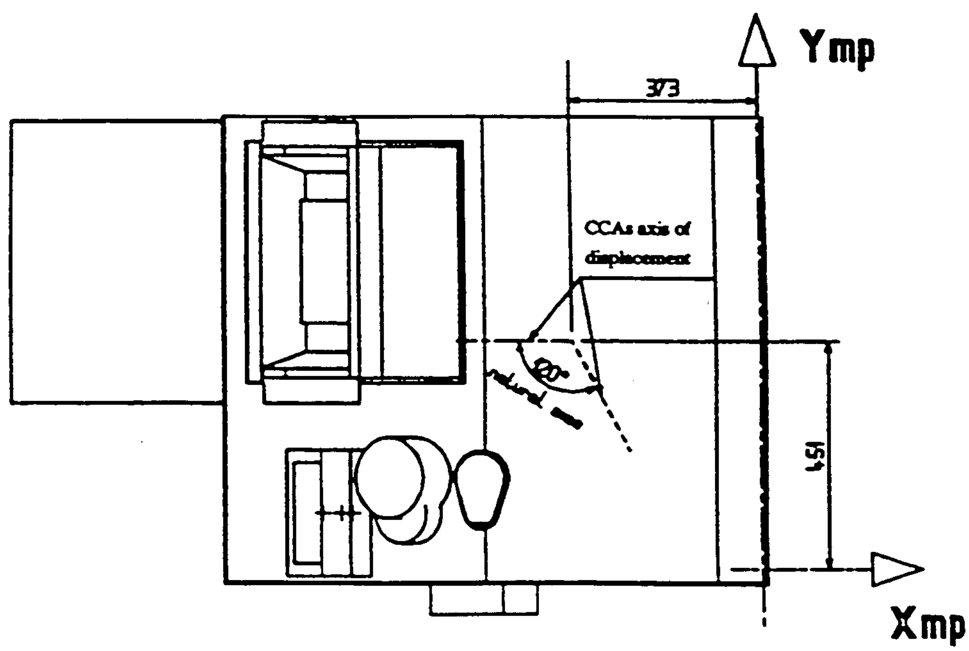
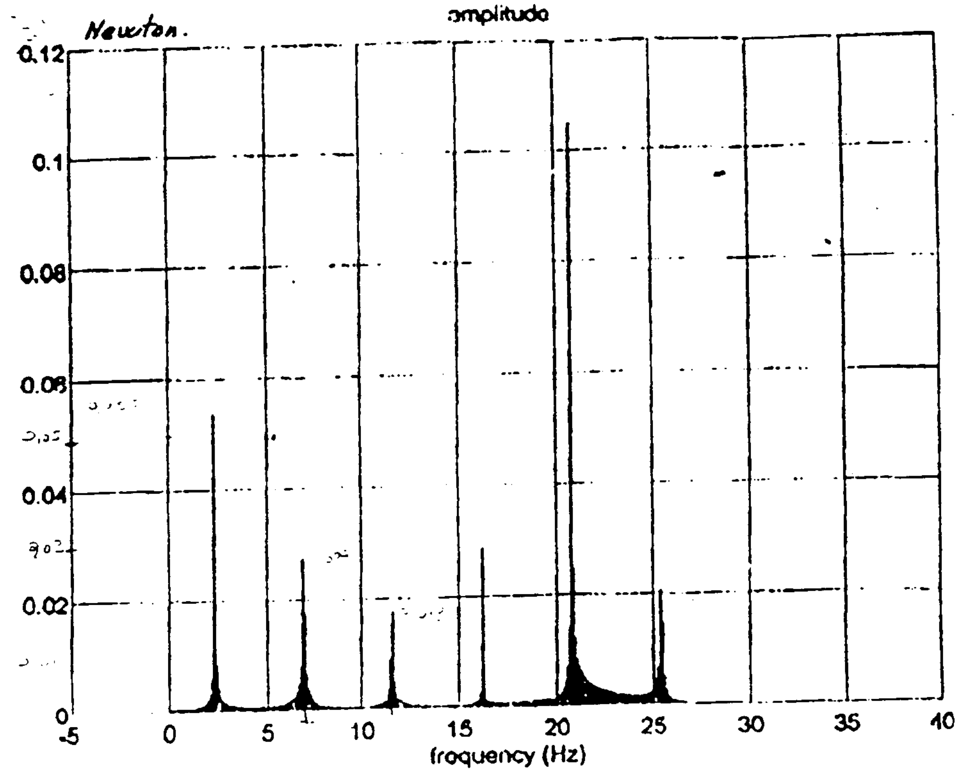


Figure 2.1/3 : IASI Cube Corner Displacement



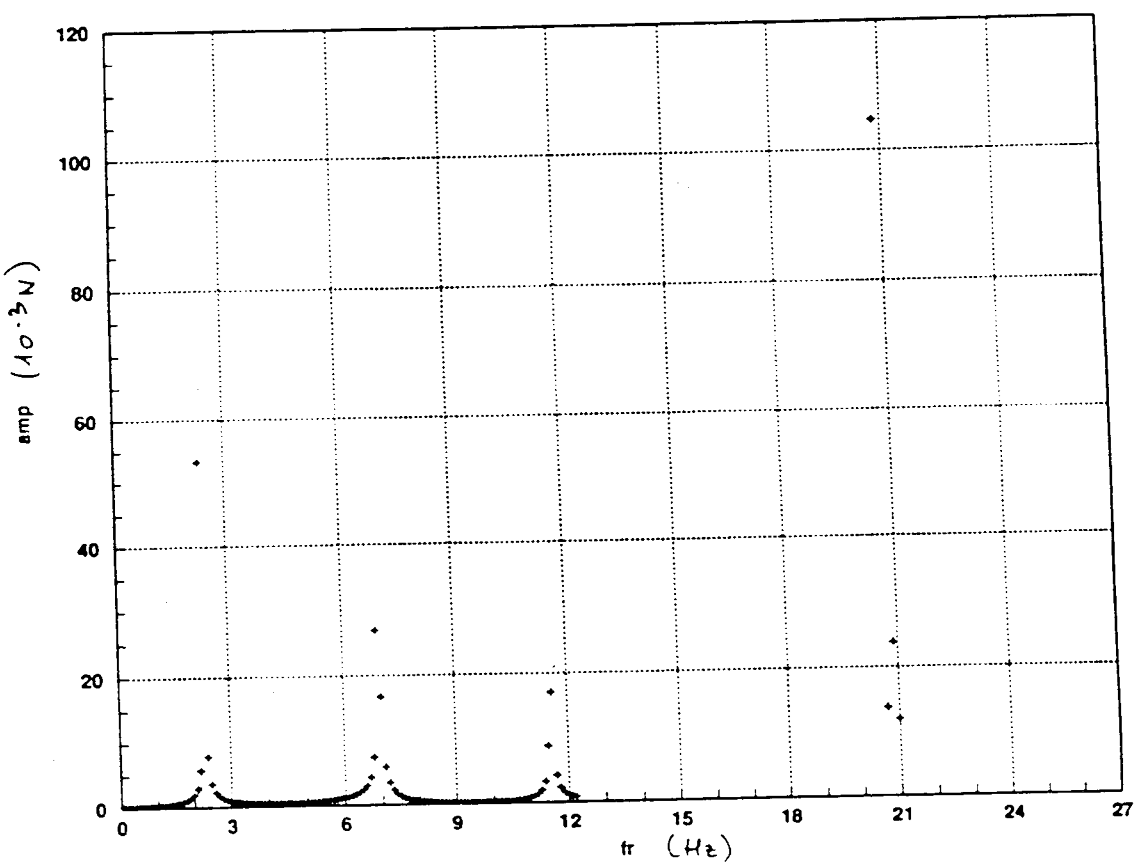


Figure 2.1/4 : IASI Cube Corner Disturbance Force

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The IASI sensor module and SEM are mounted to the spacecraft using bolts and 10 mm high GFRP low conductance stand-offs (TBC). The MEM is directly bolted to a platform radiator panel.

The bolt size, length and torque required to mount the units are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
Sensor Module				12
MEM				
SEM				

2.2.2. Reference Point (Hole)

The definitions of the Reference Points / Holes for the IASI modules are given in the Mechanical Interface Control Drawing, TBD.

2.2.3. Mounting Surfaces

The mounting surfaces are the module baseplates : + Z instrument side for the Sensor Module and (L x W) plane for MEM and SEM. The flatness of the mounting surfaces does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD μm. Each mounting foot has an area of TBD mm^2.

2.2.4. Materials

The material of the IASI Sensor Module baseplate is CFRP (TBC). The material of the MEM and SEM modules is TBD. All platform mounting interfaces are 20 mm aluminium honeycomb panel with CFRP facing skins. A carbon-carbon doubler may be used under the MEM.

2.2.5. Interface Loads

The calculated interface loads induced by the IASI modules are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
Sensor Module				
MEM				
SEM				

2.2.6. Accessibility

TBD

2.2.7. Grounding Point

The locations of the grounding points on the IASI modules are defined in TBD.

2.3. POINTING

The pointing requirements for the IASI Sensor Module are expressed at the Instrument Mounting Interface Reference Frame $F_{IASI-SM}$.

Absolute Pointing Error (Accuracy) :	± 0.15 deg. (3σ)
Absolute Measurement Error (Knowledge) :	± 0.10 deg. (3σ)
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

This only applies for the Sensor Module and not for the electronic units.

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical Interface Control Drawing, TBD. The cube has two alignment surfaces of size TBD mm^2 which are viewed from the spacecraft TBD axes.

The cube shall be covered with a cover in accordance with TBD prior to launch.

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

The co-alignment requirements are expressed between the Instrument Mounting Interface Reference Frames (F_{MI}) of each instrument.

IASI Sensor Module shall be co-aligned with AVHRR/3 to within ± 0.05 deg. (3σ).

Note that co-alignment is required with AMSU-A1 and AMSU-A2 in the reference documentation (Cf. § 1.3.).

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD.

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD.

The first natural frequencies of the IASI Sensor Module are 107.5, 110.0 and 117.0 Hz in its stowed configuration, this value having been established by analysis. For the IASI MEM and SEM units, the fist natural frequencies are TBD.

Structural Mathematical Model : TBD

2.6. MECHANISMS

2.6.1. Functional Description

Cooler Cover Deployment Mechanism

TBD

Interferometer Oscillating Masses

The cube corner mechanisms are locked during Launch up to Warm-Up, and servo-controlled (eigen-frequency ≈ 200 Hz) in operating modes.

Earth Scan

Mobile elements of the Earth scan subsystem are servo-controlled in operating modes.

2.6.2. Performances

2.7. PYROS

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

2.8.2. Removable Covers (Non-Flight Items)

2.8.3. Deployable Covers (Flight Items)

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

IASI Sensor Module and electronic units are category A instruments (autonomous thermal control). The thermal control design is based on super insulation, radiative surfaces and heaters controlled by software.

Note that, for accommodation easiness, one or both electronic modules can be accommodated inside the Payload Module, and then become Category B instruments.

The IASI modules have then the following thermal category :

IASI Sensor Module:	Category A
IASI MEM:	Category B
IASI SEM:	Category A

3.1.2. Thermal Control Philosophy

Normal Operation

IASI Sensor Module uses radiators for general heat rejection and passive coolers for maintaining the detector assemblies at operational temperature (approximately 90K).

Radiative cooling of secondary radiator to TBD K.

IASI Sensor Module configuration includes baffles around focal plane assembly and secondary radiator to prevent solar illumination and thermal views of other instruments/equipment.

Radiators are accommodated on -Ys, -Zs and -Xs sides of the Sensor Modules.

IASI MEM and SEM : TBD.

Contingency Modes

During the contingency modes the instrument is switched off. The IASI Sensor Module and SEM are maintained within their survival limits by heaters controlled by thermostats. The MEM is maintained within its limits by the platform Thermal Control Subsystem.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the IASI modules are defined in Tables 3.2/1 and 3.2/2. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C IASI	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
Sensor Module	+10	+30	-40	+60	-40
MEM	-40	+60	-40	+60	-30
SEM	-40	+60	-40	+60	-30

Table 3.2/1 : IASI Unit Acceptance Temperatures

Deg. C IASI	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
Sensor Module	+5	+35	-45	+65	-45
MEM	-45	+65	-45	+65	-35
SEM	-45	+65	-45	+65	-35

Table 3.2/2 : IASI Unit Qualification Temperatures (TBC)

Stability Requirements

There is no temperature stability requirement for the IASI modules.

3.2.2. Radiative Interfaces

The IASI Sensor Module radiators require the following minimum Gebhart factors to space :

- Focal plane assembly : 0.93 (TBC)

  Surfaces of other instruments may be permitted in the radiator field of view provided that this Gebhart factor requirement is met. In that respect, the identified interactions with AVHRR/3, HIRS/3 and the rotating MIMR main reflector are acceptable (TBC). This cooling radiator operates at a temperature of 90 K.
- Secondary radiator : 0.91 (TBC)
- -Z radiator : 0.96 (TBC)
- -Y radiator : 0.48 (TBC)
- -X radiator : 0.9 (TBC)

The IASI SEM radiators require the following minimum Gebhart factors to space :

- +Z radiator : TBD
- -X radiator: TBD

The sides of the MEM are black painted to facilitate radiation exchange with the platform interior (TBC).

3.2.3. Heater Power Budgets

The heater power budgets for the IASI modules are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
Sensor Module	TBD	TBD	TBD	TBD
SEM	TBD	TBD	TBD	TBD
Total :			69 W	63 W

The heater power concept is not applicable to MEM.

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipations of the IASI modules are constant throughout the orbit and are :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
Sensor Module		82	82	0
MEM		69	69	0
SEM		66	66	0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the IASI modules for different cases are :

Category A Units

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
Sensor Module	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)
SEM	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

Category B Units

Module / Unit	Operative Heat Transfer (Orbit Average, Watts)			
	Conductive Hot Case	Conductive Cold Case	Radiative Hot Case	Radiative Cold Case
MEM	TBD	TBD	TBD	TBD

3.2.6. Thermo-Elastic Interface

The IASI Sensor Module has an CFRP baseplate with a coefficient of thermal expansion of 2×10^{-6} / deg. C (TBC). The MEM and SEM have aluminium baseplates with a coefficient of thermal expansion of 25×10^{-6} / deg. C (TBC). The interfacing structure for all the IASI modules is aluminium honeycomb with CFRP skins with a coefficient of thermal expansion of 2.0×10^{-6} / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interfaces for the IASI modules are defined in the Mechanical Interface Control Drawing (TBD) and in § 2.2.3.

GFRP stand-offs will be used between the IASI Sensor Module and the platform -Xs floor. The total thermal conductance between the Sensor Module and the floor is TBD W/K.

GFRP stand-offs will be used between the IASI SEM and the platform -Xs floor. The total thermal conductance between the SEM and floor is TBD W/K.

A thermal interface filler will be used between the MEM and the platform radiator panel, the contact area is TBD mm^2 .

The calculated temperatures at the IASI modules conductive interfaces are TBD.

3.3.3. Radiative Interfaces

The external surfaces of the IASI Sensor Module and SEM, and the thermal finishes used are given in the Thermal Interface Drawing TBD. The Sensor Module and SEM thermal coatings are illustrated in Figure .3.3-1.

The exterior thermal finish of the MEM is black paint.

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red
	BOL	EOL	Emittance
White Paint (PSB)	0.13	0.30 TBC	0.90
Black Paint (MEM only)	N/A	N/A	0.90
Gold	0.30	0.30	0.04
VDA (Vacuum Deposited Aluminium)	0.11 TBC	0.15 TBC	0.04 TBC
SSM	0.15	0.25	0.78
Kapton (MLI ext)	0.36	0.46	0.63

IASI Material Thermo-Optical Properties

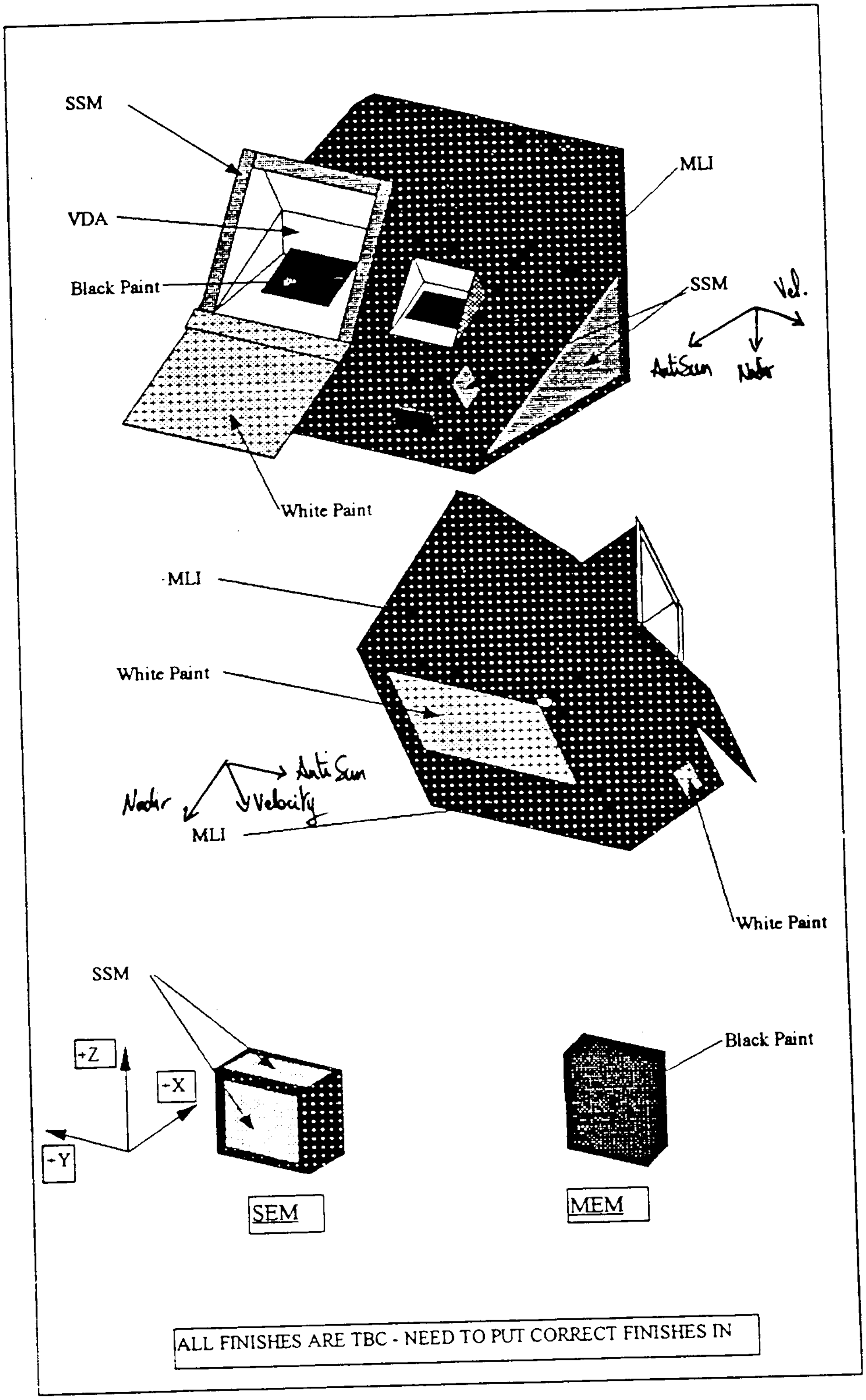


Figure 3.3/1 : IASI Module Thermal Finishes (TBC)

The radiative environmental temperatures for the IASI modules are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacity of the IASI modules is TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

3.4. THERMAL ENVIRONMENT CONDITIONS

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Input Voltage : 22-37 Volts DC unregulated

The following power buses are provided by the platform :
- equipment power bus, nominal and redundant
- equipment heater power bus, nominal and redundant (for non-operating modes)
- ICU (Instrument Control Unit) power bus, nominal and redundant
- ICU heater power bus, nominal and redundant (for non-operating modes)

IASI power consumption in nominal operations is :

Sensor Module basic power :	74 W
Main Electronics Module basic power :	62 W
Secondary Elect. Module basic power :	60 W
Total basic consumption :	196 W

4.2. COMMAND AND CONTROL INTERFACES

The command and control of the instrument is performed via the PLM OBDH bus.

IASI ICU has a nominal and redundant connection to the OBDH via a DBU supplied by the platform

In case of emergency, IASI can receive the following signals :
- equipment switch off line (EQU SOL), nominal and redundant
- depointing signal line (DSL), TBD

4.3 SCIENCE DATA INTERFACES

IASI generates packetized measurement data, that are transferred to the PLM data handling subsystem via a nominal and redundant connection via low bit rate data interface.

Read Cycle (s) :	8
Packet per 64 s :	2400
Packet Size (octet) :	5014
Packetized Data Rate (kbps) :	1500

4.4. HOUSEKEEPING TELEMETRY

Thermistor Interface :
- thermistor for equipment, nominal and redundant connection to the platform
- thermistor for ICU, nominal and redundant connection to the platform

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

IASI is responsible for the provision of the inter IASI unit harness.

5. EMC / RFC INTERFACE DESCRIPTION

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

9.1.2. Instrument Engineering Model (EM)

9.1.3. Instrument Proto-Flight Model (PFM)

9.1.4. Instrument Flight Model (FM)

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 5 years

Reliability : 0.8 over 4 years

12. PROGRAMME AND SCHEDULE

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

ASCAT

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the ASCAT Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with ASCAT responses to the generic METOP General Instrument Interface Control Document (GICD).

This ICD Outline of ASCAT reflects the definition status of the instrument at the end of the METOP spacecraft Phase A study.

1.2. INSTRUMENT PRESENTATION

The advanced wind scatterometer ASCAT is a radar measuring system exploiting Doppler principle. It operates in C-band (5.255 GHz) with a long pulse with linear frequency modulation. The ASCAT will measure the radar reflectivity of the sea surface over two 550 km wide swaths, one on either side of the satellite ground track. The measurements are accomplished by consecutive antenna operations covering all three directions of viewing : fore, mid, and after beam with 45 deg., 90 deg. and 135 deg. respectively relative to ground track. ASCAT consists of four sub-systems :

- antenna sub-system
- scatterometer front end sub-system
- radio frequency electronics sub-system
- digital control electronics sub-system

PARAMETER	VALUE	REMARK
Spatial Resolution	≤ 50 km ≤ 25 km	Along and across track
Radiometric Resolution Kpe - F/A beam 24 m/ - Mid beam - F/A beam 4 m/s - Mid beam <	Better than 3 % ≤ Thetaj/8	kpe (%) = Thetaj/8 Thetaj = Incident Angle
Radiometric Accuracy	≤ 0.46 dB ≤ 0. 57 dB	Interbeam Common Mode
Centre Frequency	5.255 GHz	
Coverage - Swath Length - Swath Width	Continuous 2 x 500 km	Full performance
Localisation Accuracy	± 5 km	Along and across track
Polarisation	VV	
Cross-polarisation	≥ 15 dB	One way propagation

Wind Mode In-Orbit Performances (TBC)

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94, Iss. 2, dated Sept. 94

Reference Documentation

ASCAT Data List
Ref. PO-LI-DOS-SC-1170 (MET0039), Dated April 1992, Iss. 2

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

ASCAT consists of three antennae, and several electronic equipments with the following part numbers and identification codes :

Sub-System / Module / Unit	Acronym	Part No	ID Code
Antennae			
Mid Antenna Assembly	ANTM		
Side Antenna Right - Fore	ANTRF		
Side Antenna Right - Aft	ANTRA		
Scatterometer Front End	SFE		
Radio Frequency Electronics			
Solid State Power Amplifier	SSPA		
Electronic Power Conditioner	EPC		
Radio Frequency Unit	RFU		
Digital Control Electronics			
Data Processing Unit	DPU		
Instrument Control Unit	ICU		
Power Distribution Unit	PDU		
Miscellaneous			
Deployment Electronics	DPE		
Wave Guide Switch	WGS		
Wave Guide Run	WGR		
Harness	-		
Mid Antenna Supporting Structure	MSS		
HRM & Deployment Sys. ANTRF	HDSF		
HRM & Deployment Sys. ANTRA	HDSA		

The overall dimensions of the modules and units are :

Module / Unit	L (Velocity)	W	H (Earth)
Antennae			
ANTM	2200 mm	870 mm	299 mm
ANTRF	3000 mm	643 mm	334 mm
ANTRA	3000 mm	643 mm	334 mm
SFE	1680 mm	475 mm	250 mm
Radio Frequency Electronics			
SSPA (2 units)	480 mm	240 mm	114 mm
EPC (2 units)	212 mm	210 mm	93 mm
RFU (2 units)	274 mm	167 mm	179 mm
Digital Control Electronics			
DPU (2 units)	285 mm	268 mm	160 mm
ICU (2 units)	285 mm	268 mm	160 mm
PDU	233 mm	212 mm	151 mm
Miscellaneous			
DPE	150 mm	150 mm	100 mm
WGS	172 mm	115 mm	82 mm
WGR			
Harness	-	-	-
Mid Antenna Support. Structure			
HDSF			
HDSA			

The dimensions respectively correspond to the L (velocity) x W x H (Earth) directions. Note that, for the antennae, these dimensions do not correspond to the in-flight position. The antennae shall nominally be in the velocity direction for the mid antenna, and the two other ones at ± 45° of the flight direction. This configuration will be reached after a deployment sequence.

Note that the SFE can be compacted to 700 x 600 x 200 mm (TBC).

Accommodation

The antennae and the SFE are externally accommodated, whereas the remaining electronic units are internally accommodated. The accommodation of the antennae shall avoid EMC conflicts. Note that there is no requirement for the mid-antenna to be accommodated on the nadir panel. The antennae cannot be broken up, and then shall be considered as single booms.

The SFE electronic equipment shall be externally accommodated as close as possible to the antennae. The other electronic equipments are mounted on their (L x W) plane inside the platform.

The harness between the ASCAT units will be supplied by the Instrument Contractor (TBC).

2.1.2. Mechanical Interface Control Drawing

The ASCAT instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The ASCAT antenna configurations are illustrated in Figures 2.1/1, 2.1/2 and 2.1/3.

2.1.3. Mass Properties

Mass

The mass properties of the ASCAT modules and units are given in Table 2.1/1. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each module or unit, $F_{ASCAT-i}$, with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the $F_{ASCAT-i}$ axes are the same as the Spacecraft Reference Frame Fs.

Moments of Inertia

The ASCAT moments of inertia are given in the following table. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each module or unit, $F_{ASCAT-i}$, with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the $F_{ASCAT-i}$ axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

Module /Unit	Moments of Inertia (kg.m^2)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}

Table 2.1/2 : ASCAT Moments of Inertia

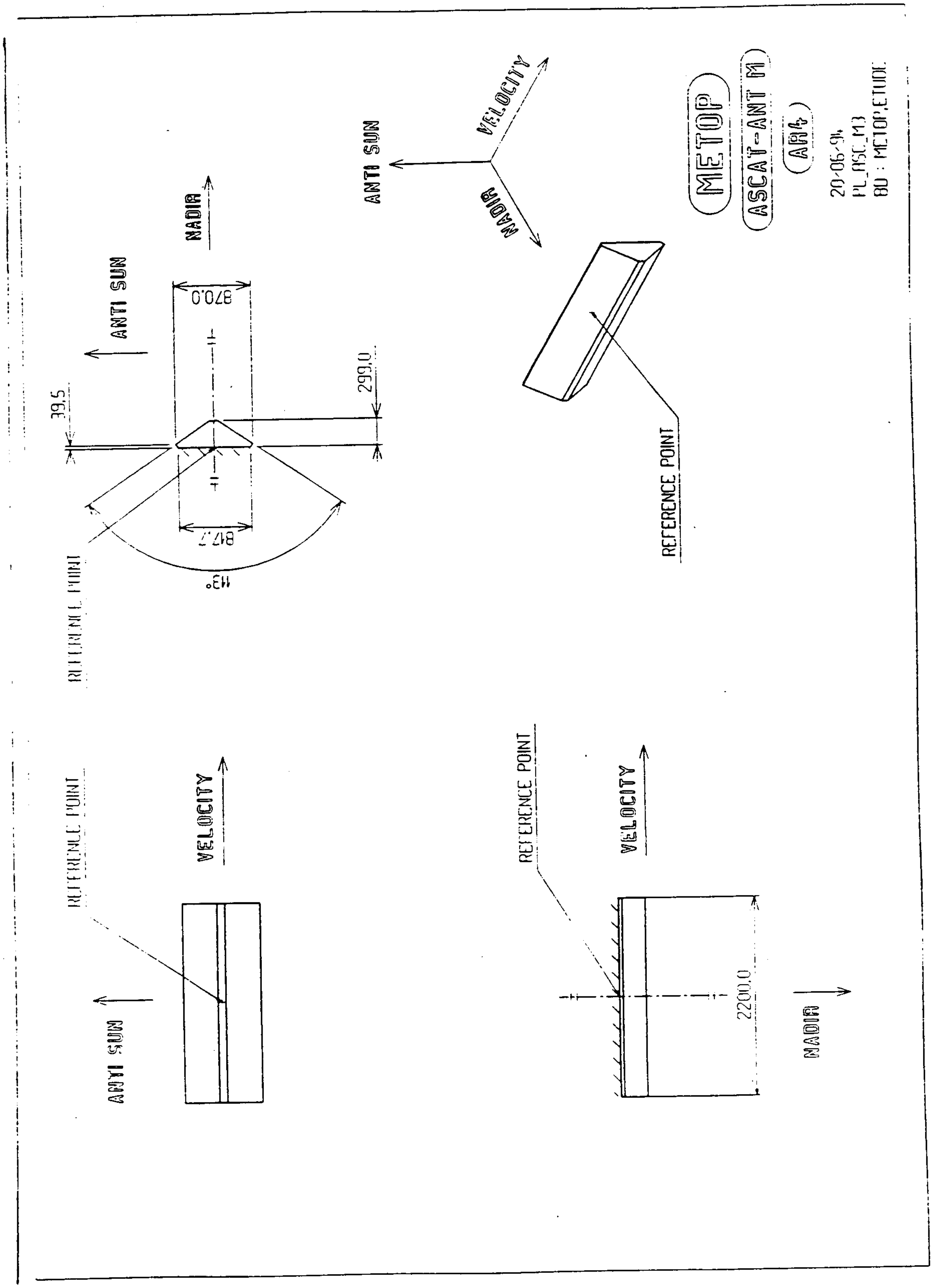


Figure 2.1/1 : ASCAT Mid Antenna Configuration

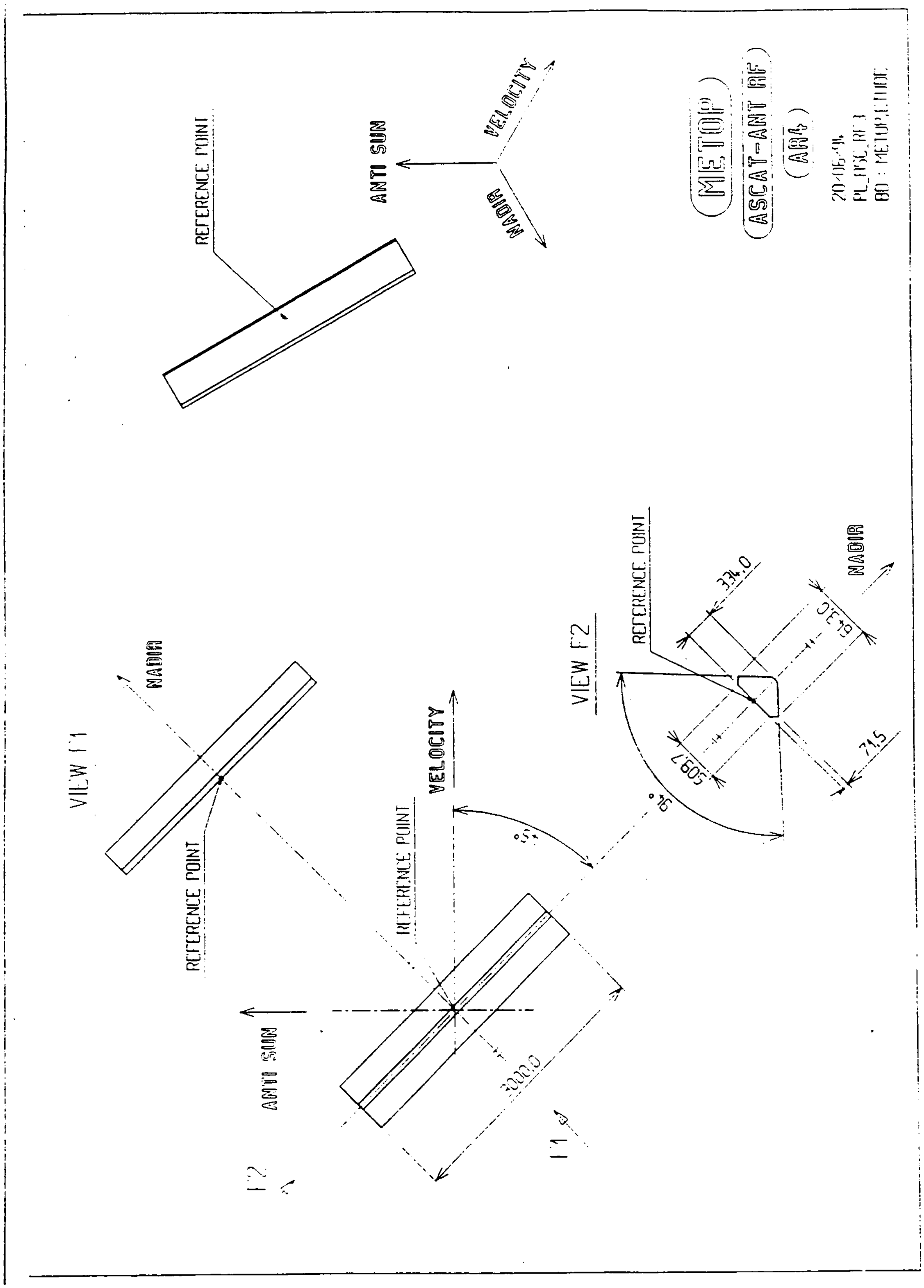


Figure 2.1/2: ASCAT Right Fore Antenna Configuration

Module / **Unit**	**Basic Mass** / **Unit** **±0.1 kg TBC**	**Centre of Mass Location (± 5 mm)**		
		$X_{ASCAT-1}$ (Sun)	$Y_{ASCAT-1}$ (Anti-velocity)	$Z_{ASCAT-1}$ (Zenith)
Antennae	-			
ANTM	22.30 kg			
ANTRF	29.20 kg			
ANTRA	29.20 kg			
SFE	13.99 kg			
RFE	-			
SSPA (2 units)	2.30 kg			
EPC (2 units)	3.38 kg			
RFU (2 units)	6.00 kg			
DCE	-			
DPU (2 units)	6.80 kg			
ICU (2 units)	6.50 kg			
PDU	3.26 kg			
Miscellaneous	-			
DPE	1.50 kg			
WGS	0.86 kg			
WGR	2.60 kg			
Harness	8.00 kg			
MSS	7.00 kg			
HDSF	9.70 kg			
HDSA	12.80 kg			

TOTAL : 190.37 kg

Table 2.1/1 : ASCAT Mass Properties

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

No moving part other than those used during deployment of the antennae.

2.1.4.2. Continuous and Recurring Transient Events

None

2.1.4.3. Induced Disturbance Torque Effect

None

2.1.4.4. Flexible Modes

TBD

2.1.5. Field of View Definition

The antenna fields of view are illustrated in Figures 2.1.5/1, 2.1.5/2 and 2.1.5/3.

Mid antenna

The mid antenna boresight is defined as the nadir direction. The instrument field of view definition is :

- vertex : all along the antenna (Cf. drawing)
- Spacecraft provision :
  - cross-track scan plane : ± 60.0 deg.
  - Orbit plane : ± 0.6 deg.

Side antennae

The mid antenna boresight is defined as the nadir direction. The instrument field of view definition is :

- vertex : all along the antenna (Cf. drawing)
- Spacecraft provision :
  - cross-track scan plane : ± 70.0 deg.
  - Orbit plane : ± 0.6 deg.

Note that small protrusions in the ASCAT antenna field of view, such as PLM antenna or small structures, can be tolerated.

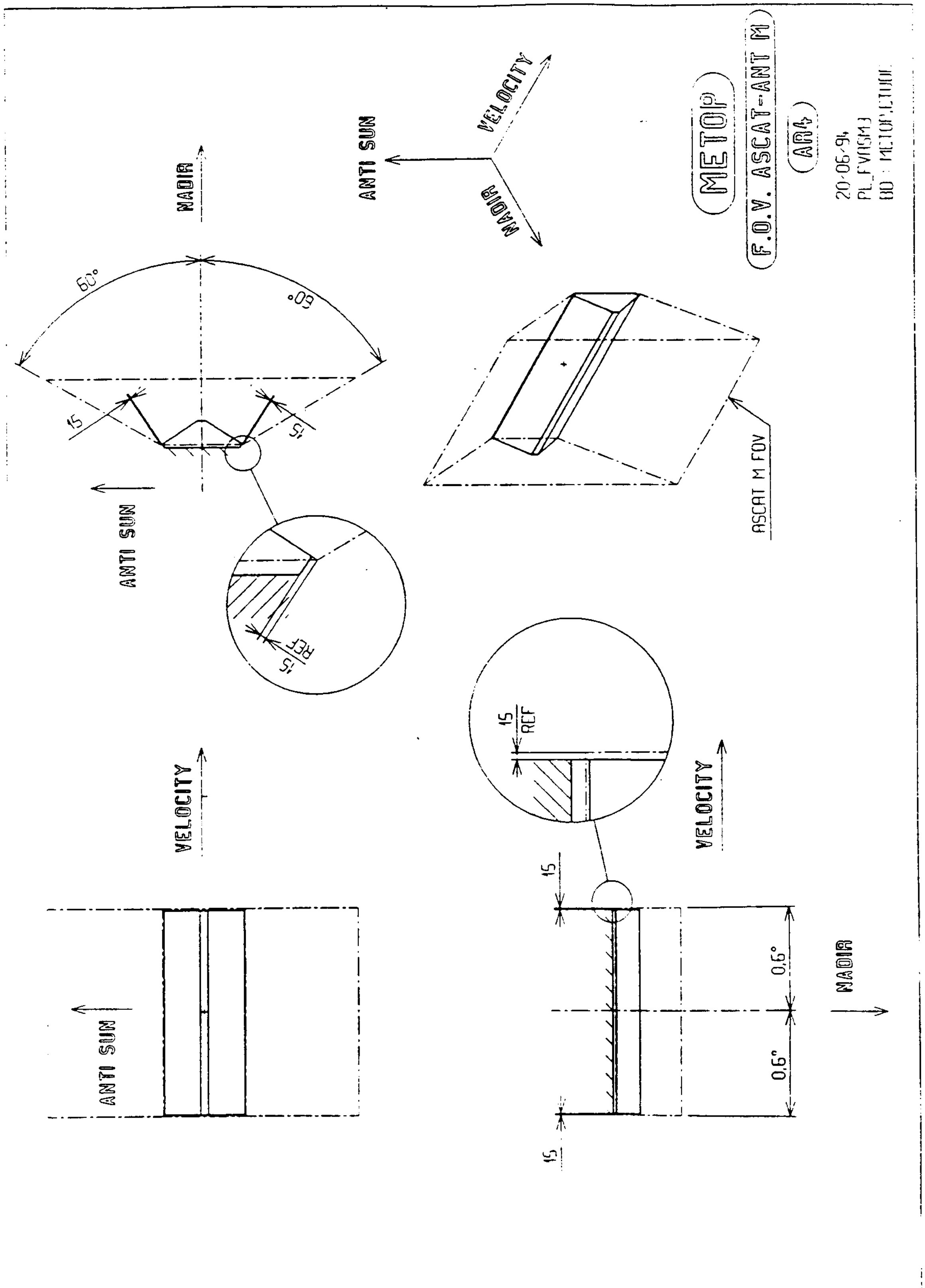


Figure 2.1.5/1 : ASCAT Mid Antenna Field of View

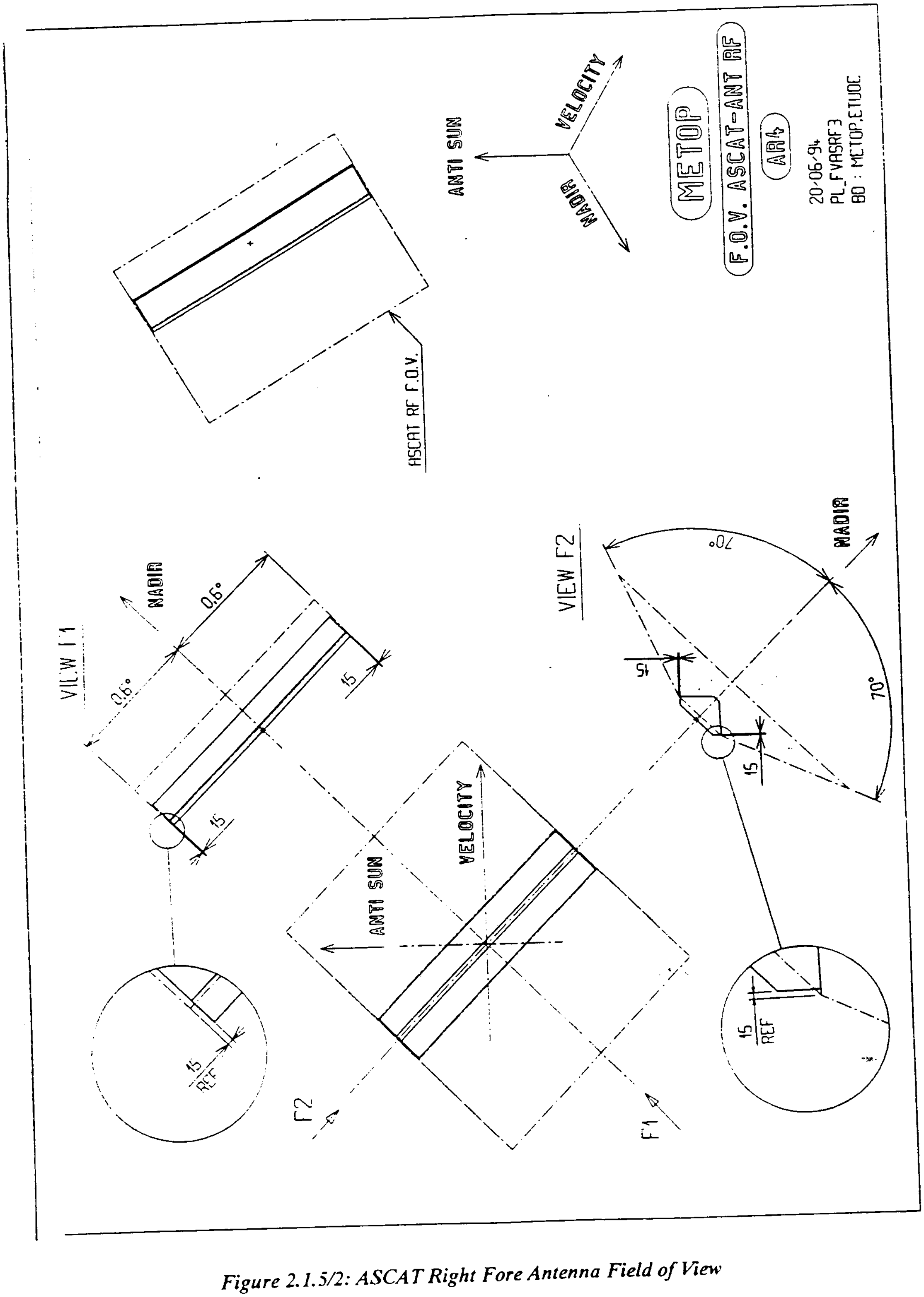


Figure 2.1.5/2: ASCAT Right Fore Antenna Field of View

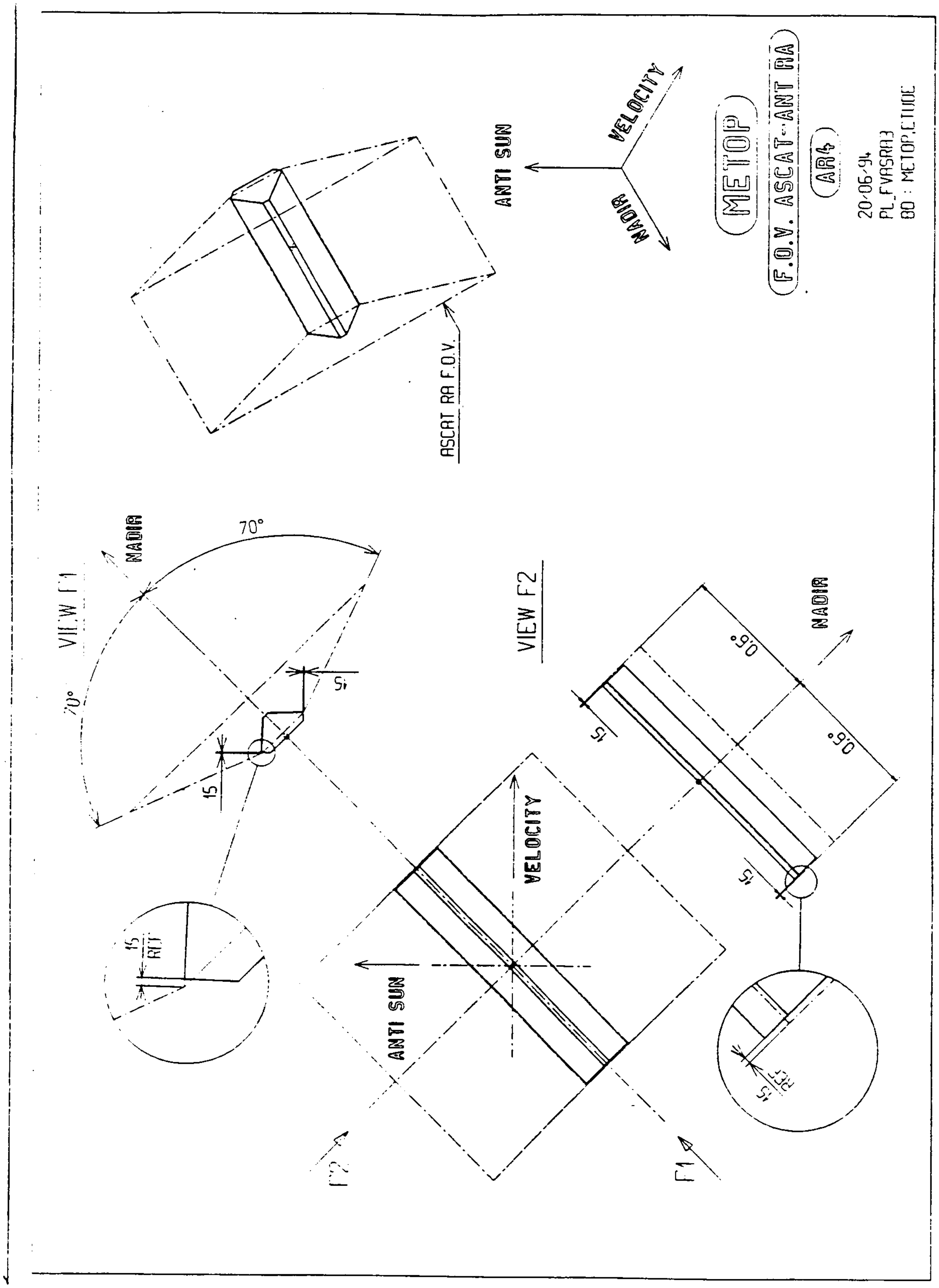


Figure 2.1.5/3 : ASCAT Right Aft Antenna Field of View

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The ASCAT antennae and SFE are mounted to the spacecraft using TBD. The other electronic equipments are directly bolted to a platform radiator panel.

The bolt size, length and torque required to mount the units are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity

2.2.2. Reference Point (Hole)

The definitions of the Reference Points / Holes for the ASCAT units are given in the Mechanical Interface Control Drawing, TBD.

2.2.3. Mounting Surfaces

Antennae : TBD.

The mounting surfaces of the electronic equipments are the unit baseplates : (L x W) plane. They can be accommodated in any direction. The flatness of the mounting surfaces does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of TBD mm^2.

2.2.4. Materials

Antennae : TBD.

The material of the electronic equipments is TBD. Platform mounting interfaces are 20 mm aluminium honeycomb panel with CFRP facing skins. A carbon-carbon doubler may be used under the inside electronic equipments.

2.2.5. Interface Loads

The calculated interface loads induced by the ASCAT units are .

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)

2.2.6. Accessibility

TBD

2.2.7. Grounding Point

The locations of the grounding points on the ASCAT units are defined in TBD.

2.3. POINTING

The pointing requirements for the ASCAT are expressed at the Instrument Mounting Interface Reference Frame $F_{ASCAT-i}$.

Absolute Pointing Error (Accuracy) :	TBD
Absolute Measurement Error (Knowledge) :	TBD
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

This only applies for the antennae (at the mounting points) and not for the electronic units.

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube(s) is given in the Mechanical Interface Control Drawing, TBD. The cube has two alignment surfaces of size TBD mm² which are viewed from the spacecraft TBD axes.

The cube shall be covered with a cover in accordance with TBD prior to launch.

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

TBD.

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD.

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequencies of the ASCAT units, in the stowed and deployed configurations, are TBD.

2.6. MECHANISMS

2.6.1. Functional Description

Antenna Deployment Mechanism

TBD

2.6.2. Performances

2.7. PYROS

2.8. INSTRUMENT APERTURE COVERS

None

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

The ASCAT units have the following thermal category :

Subsystem	Units	Category
Antenna	ANTM, ANTRF, ANTRA	A
SFE	SFE	A
RFE	SSPA, EPC, RFU	B
DCE	DPU, ICU, PDU	B
Miscellaneous	DPE, WGS	B
	MSS, HDSF, HDSA	A

3.1.2. Thermal Control Philosophy

Normal Operation

All Category A units are controlled by passive means.

All Category B units are controlled by the platform thermal control subsystem which uses passive thermal control and possibly heaters during cold BOL conditions.

Contingency Modes

Category A Units : TBD.

All category B units are maintained within its limits by the platform thermal control subsystem.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the ASCAT units are defined in Tables 3.2/1 and 3.2/2. The Temperature Reference Points at which these temperatures apply is defined in TBD.

Stability Requirements

There is no temperature stability requirements for the ASCAT units.

Deg. C ASCAT	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
Antennae					
ANTM	TBD	TBD	TBD	TBD	TBD
ANTRF	TBD	TBD	TBD	TBD	TBD
ANTRA	TBD	TBD	TBD	TBD	TBD
SFE	TBD	TBD	TBD	TBD	TBD
RFE					
SSPA	-5	+40	-30	+70	-25
EPC	-5	+40	-30	+70	-25
RFU	-5	+40	-30	+70	-25
DCE					
DPU	-5	+40	-40	+70	-25
ICU	-10	+50	-40	+70	-25
PDU	-10	+50	-40	+70	-25
Miscellaneous					
DPE	TBD	TBD	TBD	TBD	TBD
WGS	TBD	TBD	TBD	TBD	TBD
WGR	TBD	TBD	TBD	TBD	TBD
Harness	TBD	TBD	TBD	TBD	TBD
MSS					
HDSF					
HDSA					

Table 3.2/1 : ASCAT Unit Acceptance Temperatures

Deg. C ASCAT	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
Antennae					
ANTM	TBD	TBD	TBD	TBD	TBD
ANTRF	TBD	TBD	TBD	TBD	TBD
ANTRA	TBD	TBD	TBD	TBD	TBD
SFE	TBD	TBD	TBD	TBD	TBD
RFE					
SSPA	-10	+45	-35	+75	-30
EPC	-10	+45	-35	+75	-30
RFU	-10	+45	-35	+75	-30
DCE					
DPU	-10	+45	-45	+75	-30
ICU	-15	+55	-45	+75	-30
PDU	-15	+55	-45	+75	-30
Miscellaneous					
DPE	TBD	TBD	TBD	TBD	TBD
WGS	TBD	TBD	TBD	TBD	TBD
WGR	TBD	TBD	TBD	TBD	TBD
Harness	TBD	TBD	TBD	TBD	TBD
MSS					
HDSF					
HDSA					

Table 3.2/2 : ASCAT Unit Qualification Temperatures

3.2.2. Radiative Interface

SFE : TBD.

The sides of the category B units are black painted to facilitate radiation exchange with the platform interior (TBC).

3.2.3. Heater Power Budgets

The heater power budgets for the ASCAT units are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
Antennae				
SFE				
ANTM Support				
HDSF				
HDSA				

The heater power concept is not applicable to Category B units.

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipations of the ASCAT units are constant throughout the orbit and are :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
Antennae				
ANTM	0.0	TBD	TBD	0.0
ANTRF	0.0	TBD	TBD	0.0
ANTRA	0.0	TBD	TBD	0.0
SFE	0.0	20.15	20.15	0.0
RFE				
SSPA A / B	0.0	83.03 / 0.0	83.03 / 0.0	0.0
EPC A / B	0.0	55.23 / 0.0	55.23 / 0.0	0.0
RFU A / B	0.0	24.86 / 0.0	24.86 / 0.0	0.0
DCE				
DPU A / B	0.0	25.83 / 0.0	25.83 / 0.0	0.0
ICU A / B	19.25 / 0.0	19.25 / 0.0	19.25 / 0.0	0.0
PDU	0.0	17.46	17.46	0.0
Miscellaneous				
DPE	0.0	Deployment Only	Deployment Only	0.0
WGS	0.0	0.0	0.0	0.0
WGR	0.0			0.0
Harness	0.0	TBD	TBD	0.0
HDSF	0.0	Deployment Only	Deployment Only	0.0
HDSA	0.0	Deployment Only	Deployment Only	0.0

ASCAT Unit Thermal Dissipation

3.2.6. Heat Exchange Budgets

The calculated heat transfer between the platform and the ASCAT units for different cases are

Category A Units

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
Antennae	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)
SFE	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)
MSS	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)
HDSF	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)
HDSA	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

Category B Units

Module / Unit	Operative Heat Transfer (Orbit Average, Watts)			
	Conductive Hot Case	Conductive Cold Case	Radiative Hot Case	Radiative Cold Case
RFE				
SSPA A / B				
EPC A / B				
RFU A / B				
DCE				
DPU A / B				
ICU A / B				
PDU				
Miscellaneous				
DPE				
WGS				
WGR				
Harness				

3.3.7. Thermo-Elastic Interface

The interfacing platform structure for all the ASCAT units is aluminium honeycomb with CFRP skins with a coefficient of thermal expansion of 2.0 x 10^{-6} / deg. C (TBC). The ASCAT units are TBD.

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interfaces for the ASCAT units is defined in the Mechanical Interface Control Drawing (TBD) and in § 2.2.3. The thermal blankets for the SFE will be driven by the configuration exercise outcomes.

Thermal conductance : TBD.

Category B unit baseplate contact areas : TBD.

The calculated temperatures at the ASCAT units conductive interfaces are TBD.

3.3.3. Radiative Interfaces

The external surfaces of the ASCAT Category A units, and the thermal finishes used are given in the Thermal Interface Drawing TBD.

The exterior thermal finish of the Category B units is black paint.

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red
	BOL	EOL	Emittance

ASCAT Material Thermo-Optical Properties

The radiative environmental temperatures for the ASCAT units are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacities of the ASCAT units are TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

3.4. THERMAL ENVIRONMENT CONDITIONS

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Input Voltage : 22-37 Volts DC unregulated

The unregulated power is supplied to the instrument ICU (nominal and redundant) which is in charge of supplying power to all the instrument units.

ASCAT power consumption is as follows.

Units	Redundancy	Operation	Pre-Op.	Stand-By
Antennae	-	0	0	0
SFE	Internal	13.00 W	13.00 W	0
SSPA	External	117.54 W	1.50 W	0
EPC	External	50.21 W	3.50 W	0
RFU	External	22.60 W	22.60 W	0
DPU	External	23.30 W	23.30 W	0
ICU	External	17.50 W	17.50 W	17.50 W
PDU	Internal	15.87 W	5.29 W	0
WGS	Internal	0	0	0
DPE	-	DeploymentTBD	-	-
Harness	-	2.36 W TBC	TBD	TBD

Total	Operational :	262.39 W
	Pre-Operational :	86.69 W
	Stand-by :	17.50 W

4.2. COMMAND AND CONTROL INTERFACES

The command and control of the instrument is performed via the PLM OBDH bus

ASCAT ICU has a nominal and redundant connection to the OBDH via a DBU supplied by the platform.

In case of emergency, ASCAT can receive the equipment switch off line (EQU SOL), nominal and redundant.

Deployment : TBD

4.3 SCIENCE DATA INTERFACES

ASCAT generates packetized measurement data, that are transferred to the PLM data handling subsystem via a nominal and redundant connection via low bit rate data interface.

The data transfer is constant with a 43.530 kbps rate.

4.4. HOUSEKEEPING TELEMETRY

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

ASCAT is responsible for the provision of the inter ASCAT unit harness.

5. EMC / RFC INTERFACE DESCRIPTION

RF Transmitter Characteristics

The ASCAT RF transmitter has the following specified characteristics :

ASCAT	Side Beam	Mid Beam
CF	5.225 GHz	
Pout	50.8 dBm	
BW	124 kHz	411 kHz
Mod	12 kHz/ms	50 kHz/ms
PW	10.32 ms	8.22 ms
PRF	29.63 Hz	

RF Receiver Characteristics

The ASCAT RF receiver has the following specified characteristics :

CF	BW	Sensitivity
5.225 GHz	600 kHz	- 154 dBm

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

9.1.2. Instrument Engineering Model (EM)

9.1.3. Instrument Proto-Flight Model (PFM)

9.1.4. Instrument Flight Model (FM)

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

ASCAT is continuously on along the orbit. The ASCAT instrument is used for wind measurement over ocean. Due to the swath geometry the required duty cycle in operational mode approaches 100%.

Commissioning : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

Yaw steering highly preferable.

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

Orbit Knowledge Requirement

Orbit prediction accuracy :	N/A	
Orbit restitution accuracy :	Radial <	TBD
	Along track <	5 km
	Across track <	5 km

10.5. INSTRUMENT OPERATION MANUAL

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 4 years (TBC)

Reliability : TBD

12. PROGRAMME AND SCHEDULE

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

MIMR

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the MIMR Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with MIMR responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

MIMR stands for Multi-Frequency Imaging Microwave Radiometer. It is a 20 receiver, 6 frequency passive microwave radiometric system. It receives both vertically and horizontally linear polarized radiation between 6.8 and 89.0 GHz. The receiver is based upon a total power radiometer configuration.

The instrument consists of a parabolic reflector of dimensions 1.6 x 1.4 m, illuminated by a set of 10 feed horns. The reflector and feed horns are mounted on a drum enclosing the receivers, data handling equipment, the command and control part, and the power equipment.

MIMR uses a conical scan which views the Earth with an incident angle of 55 deg. MIMR measures geophysical parameters related to the atmosphere, the ocean, the cryosphere and the land.

The most important parameters measured are the total water vapour content, total liquid water content, rain rate and cloud extension of the atmosphere, typhoon monitoring, ice content of clouds, wind speed at sea surface, sea surface temperature, ice and ice mapping, snow cover over land, permanent frost, soil moisture and vegetation characteristics.

MIMR performance characteristics are the following :

Channel	1	2	3	4	5	6
Pixel (along track) km	88	56	33	30	17	7
Pixel (across track) km	88	56	33	30	17	7
Sample Distance km (along track)	13.22	13.22	13.22	13.226	6.61	3.3
Sample Distance km (across track)	14.8	7.4	7.4	7.4	3.7	1.85
Radiometric Sensitivity (deg. K)	0.2	0.4	0.5	0.5	0.5	0.7
Radiometric Stability (deg. K)		0.4	0.5	0.5	0.5	0.5
Radiometric Accuracy (deg. K)	1	1	1.5	1.5	1.5	1.5

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94, Iss. 2, dated Sept. 94

Reference Documentation

MIMR Interface Control Requirements Specification Document
Ref. PO-RS-ALS-MI-1009 (MET0038), Dated May 1993, Iss. 1

MIMR Torque Disturbance Budget
Ref. PO-TN-ALS-MI-1012 (MET0188), Dated December 1993, Iss. 1

MIMR Uncompensated Momentum Budget
Ref. PO-TN-ALS-MI-1014 (MET0189), Dated December 1993, Iss. 1

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

ARIANE 5 Concept

MIMR consists of a single unit that deploys backwards once in orbit. It is characterized by a continuous rotation of its antenna..

The total envelope is :

L (Velocity) x W x H (Earth) 954 x 1485 x 1928 mm in the stowed configuration.
1470 x 1485 x 3208 mm in the deployed configuration.

ARIANE 4 Concept

For the METOP ARIANE 4 configuration, a new MIMR concept shall be considered mainly in order to guarantee the clearance of the instrument cold calibration towards the cold space. A new envelope has been defined according to the following drivers :

- no protrusion in the authorized ARIANE 4 fairing envelope,
- no protrusion in the platform solar array stowed envelope and swept volume during primary deployment,
- no protrusion in the thruster cone,
- in case of MIMR deployment failure, no protrusion in the AVHRR/3, HIRS/3, AMSU-A1 and MHS radiators, nor in the AVHRR/3 and HIRS/3 top radiant cooler radiators.

The resulting envelope is illustrated in Figure 2.1/3, and defined in Figure 2.1/4.

The detailed design issues of this new concept shall be covered in the forthcoming study phases. It appears that a MIMR concept within this envelope is a workable solution. However the following changes seem mandatory :

- a new concept for reflector support shall be designed
- MIMR will be split into several units : one major reflector module accommodated outside the platform and some electronic units accommodated inside the payload module.

The reflector module shall remain inside the authorized envelope. Special attention shall be paid to consider a MIMR cold calibration field of view that does not intercept any obstacle from the platform balcony

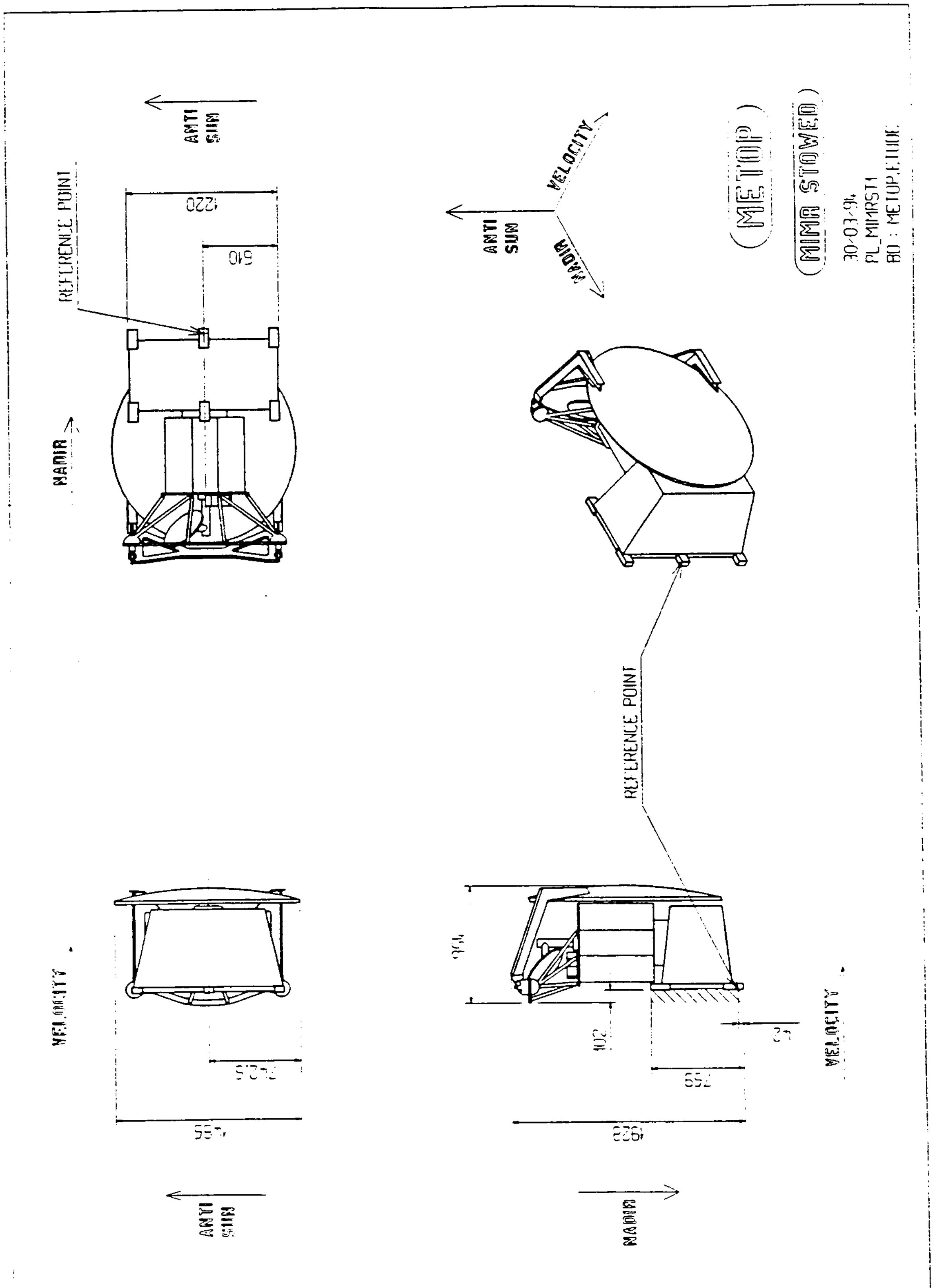


Figure 2.1/1 : MIMR Stowed Configuration (ARIANE 5)

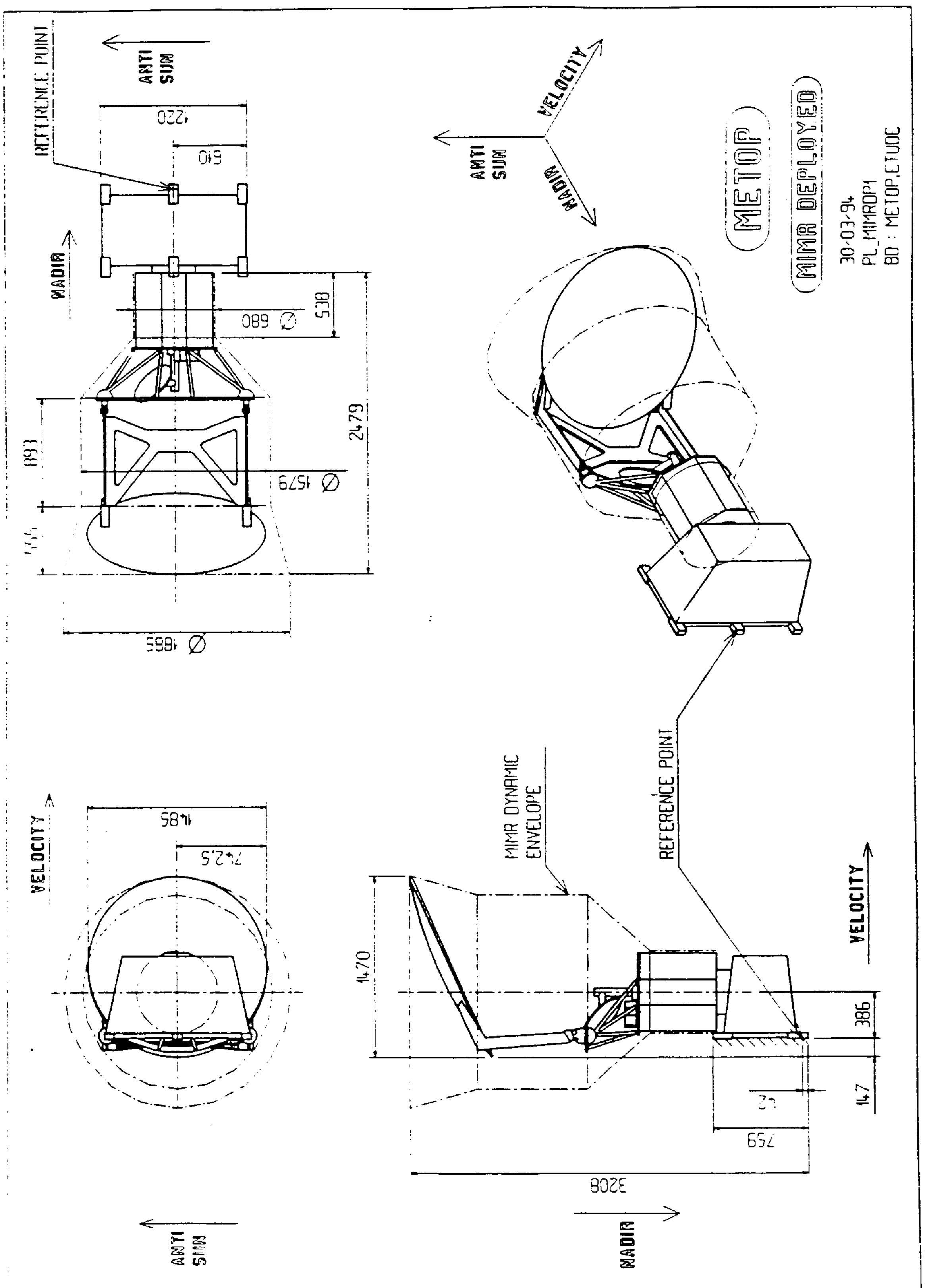
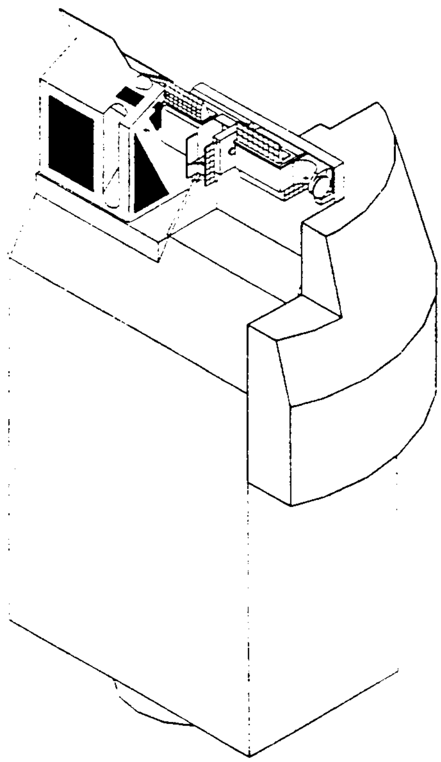


Figure 2.1/2 : MIMR Deployed Configuration (ARIANE 5)



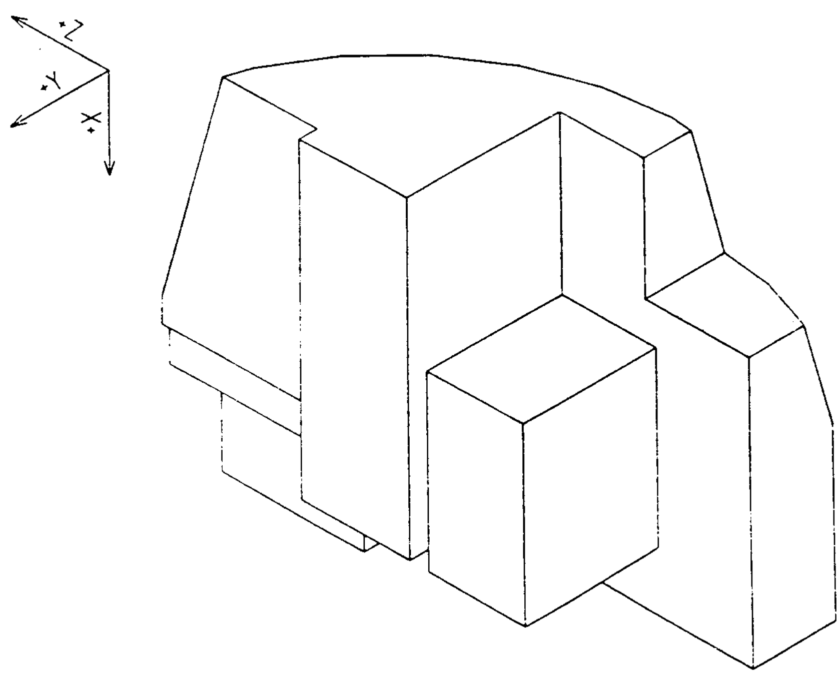


Figure 2.1/3 : MIMR Authorized Envelope (ARIANE 4)

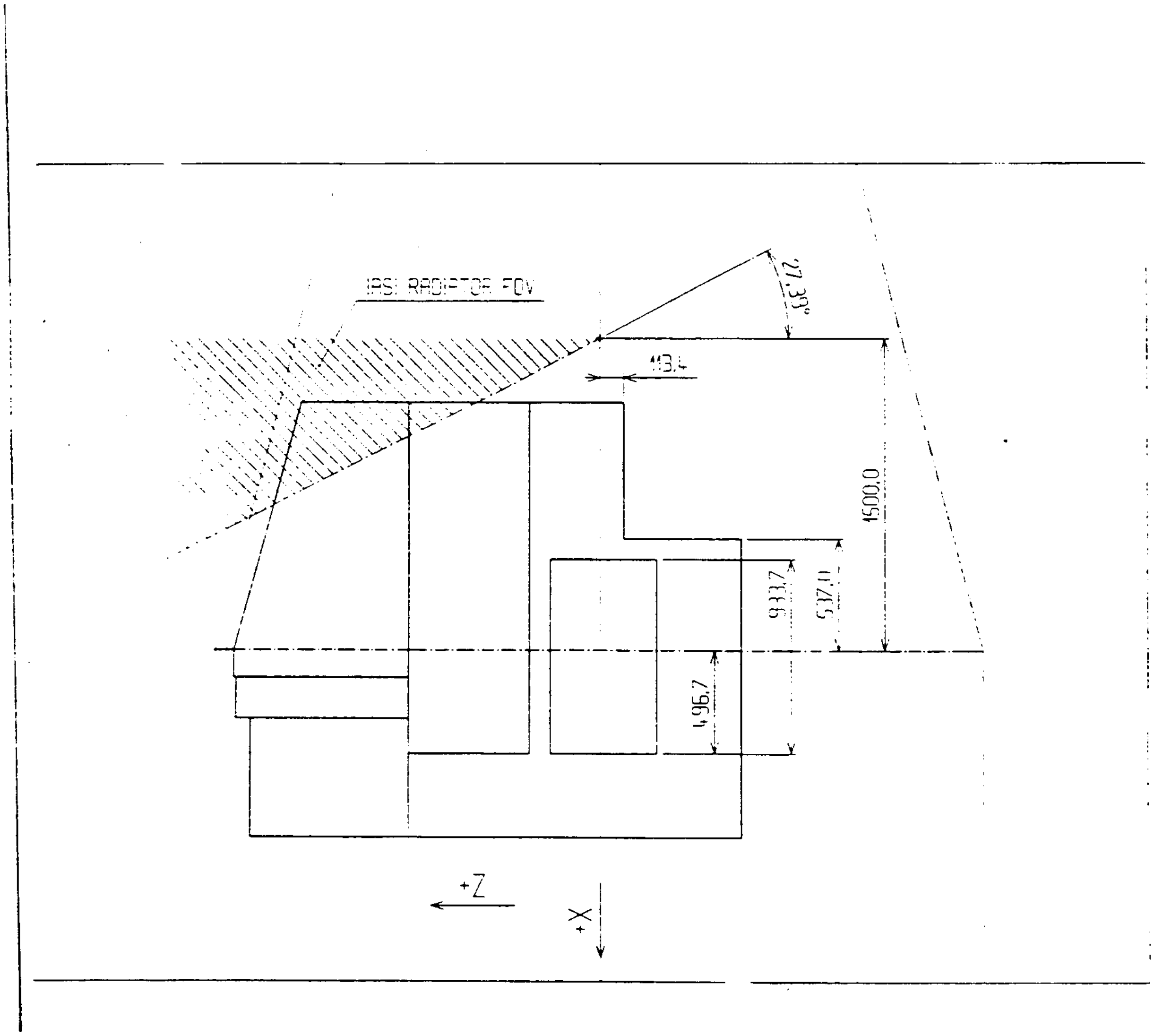


Figure 2.1/4 : MIMR Envelope Definition (ARIANE 4)

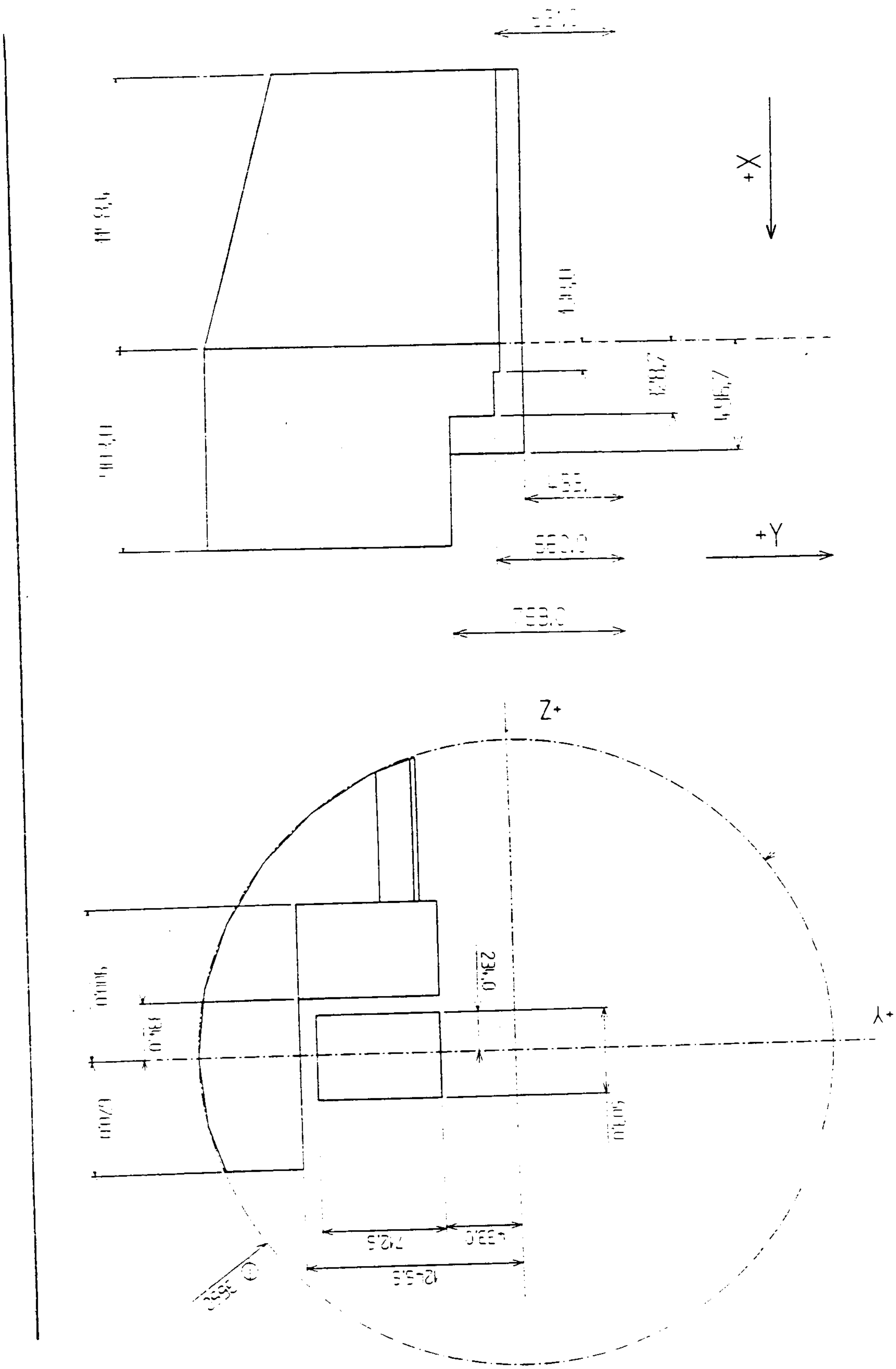


Figure 2.1/4 : MIMR Envelope Definition (Continue, ARIANE 4)

MIMR is composed of 4 separated modules with the following part numbers and identification codes :

Module / Unit	Acronym	Part No	ID Code
Sensor Module	-		
MCU	MCU		
ICPU/F (2 units)	ICPU/F		
LVPS (2 units)	LVPS		

The overall dimensions of the modules and units are :

Module / Unit	L (Velocity)	W	H (Earth)
Sensor Module	TBD	TBD	TBD
MCU	180 mm	175 mm	190 mm
ICPU/F (2 units)	210 mm	110 mm	265 mm
LVPS (2 units)	190 mm	92 mm	210 mm

2.1.2. Mechanical Interface Control Drawing

The MIMR instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The ARIANE 5 MIMR stowed and deployed configurations are illustrated in Figures 2.1/1 and 2.1/2. The dynamic envelope is also sketched in the latter drawing.

For the ARIANE 4 concept, the reflector module envelope is illustrated in Figures 2.1/3 and 2.1/4.

2.1.3. Mass Properties

ARIANE 5 Concept Mass

MIMR basic mass : 150 kg

ARIANE 4 Concept Mass

The mass properties of the MIMR instrument are given in the following table. The mass values are with a TBD contingency. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each module or unit, $F_{MIMR\text{-}i}$, with the origin being at the reference mounting hole locations as defined in the Mechanical Interface Control Drawing, TBD. The directions of the $F_{MIMR\text{-}i}$ axes are the same as the Spacecraft Reference Frame Fs.

Module / Unit	Current Mass / Unit ±0.1 kg TBC	Centre of Mass Location (± 5 mm)		
		X_{MIMR-i} (Sun)	Y_{MIMR-i} (Anti-velocity)	Z_{MIMR-i} (Zenith)
Sensor Module	146.4 kg			
MCU	3.6 kg			
ICPU/F (2 units)	3.5 kg			
LVPS (2 units)	1.5 kg			
TOTAL :	160.0 kg			

Table 2.1/1 : MIMR Mass Properties

Moments of Inertia

The MIMR moments of inertia are as follows. The co-ordinate systems used are the Instrument Mounting Interface Reference Frames for each module or unit, F_{MIMR-i} , with the origin being at the reference mounting hole locations as defined in the Mechanical Interface Control Drawing, TBD. The directions of the F_{MIMR-i} axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

Module /Unit	Moments of Inertia (kg.m^2)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
Sensor Module - Stowed						
Sensor Module - Deployed						
MCU						
ICPU/F (2 units)						
LVPS (2 units)						

Table 2.1/2 : MIMR Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

Reflector deployment , Scan/scnubber release, Scan ramp up : TBD

2.1.4.2. Continuous and Recurring Transient Events

In operation. MIMR reflector rotates at a constant angular velocity (26 rpm). The unbalance values are clearly described in MIMR Torque Disturbance Budget. Note that the attached fax (annex to this ICD Outline) that clearly states on the understanding of this document.

Uncompensated momentum : Cf. MIMR Uncompensated Momentum Budget.

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

2.1.5. Field of View Definition

Earth Scanning

- Vertex : Reflector
- The boresight is inclined by 46.4 deg. of the scan axis (Z axis)
- The spacecraft allocation is ± 50 deg. rotation around the scan axis (Z axis)

Cold Calibration

- Vertex : Small reflector
- Boresight : Cf. Drawing 2.1.5/1
- Shape : ± 25 deg.

The hot calibration is performed by the instrument itself and then is transparent to the platform.

MIMR fields of view are illustrated in Figure 2.1.5/1.

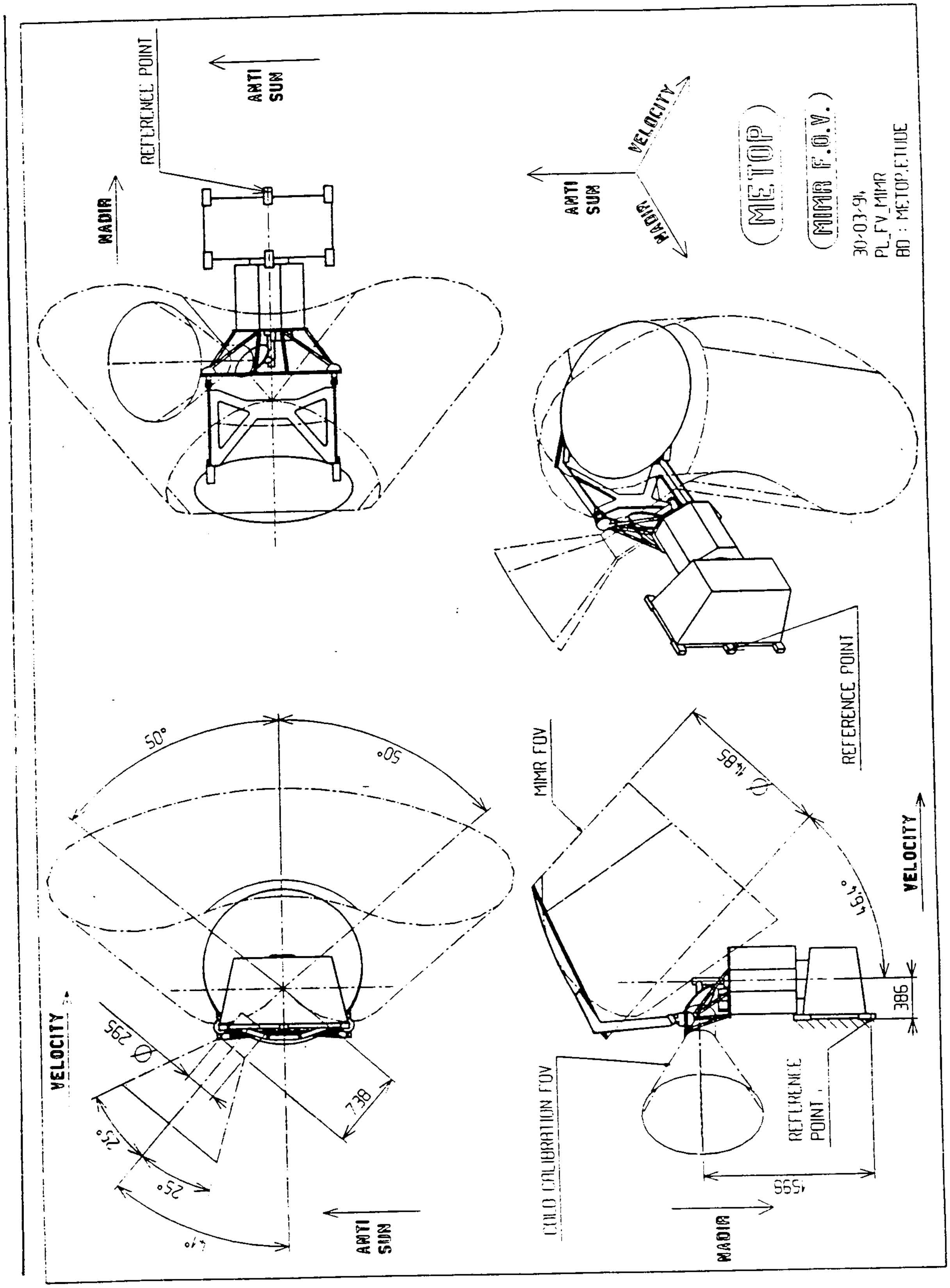


Figure 2.1.5/1 : MIMR Field of View (with ARIANE 5 Concept)

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The MIMR Sensor Module is mounted to the spacecraft using TBD. The electronic equipments are directly bolted to a platform radiator panel.

The bolt size, length and torque required to mount the units are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity

2.2.2. Reference Point (Hole)

The definitions of the Reference Points / Holes for the MIMR units are given in the Mechanical Interface Control Drawing, TBD.

2.2.3. Mounting Surfaces

The MIMR Sensor Module shall be mounted on the velocity side (-Y) of the platform, and at the top of the platform (cold calibration field of view constraint). The interaction with the thrusters shall be addressed.

The mounting surfaces of the electronic equipments are the unit baseplates : (L x W) plane. They can be accommodated in any direction.

The flatness of the mounting surfaces does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of TBD mm^2.

2.2.4. Materials

Sensor Module : TBD.

The material of the electronic equipments is TBD. Platform mounting interfaces are 20 mm aluminium honeycomb panel with CFRP facing skins. A carbon-carbon doubler may be used under the inside electronic equipments.

2.2.5. Interface Loads

The calculated interface loads induced by the MIMR units are .

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)

2.2.6. Accessibility

Accessibility on the +X (METOP) direction is required.

2.2.7. Grounding Point

The locations of the grounding points on the MIMR units are defined in TBD.

2.3. POINTING

The pointing requirements for the MIMR Sensor Module are expressed at the Instrument Mounting Interface Reference Frame $F_{MIMR\text{-}SM}$.

Absolute Pointing Error (Accuracy) :	TBD
Absolute Measurement Error (Knowledge) :	± 0.05 deg. (3σ) TBR
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

This only applies for the Sensor Module and not for the electronic units.

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical interface Control Drawing, TBD. The cube has two alignment surfaces of size TBD mm^2 which are viewed from the spacecraft TBD axes.

The cube shall be covered with a cover in accordance with TBD prior to launch.

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

TBD

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequencies of the MIMR units, in the stowed and deployed configurations, are TBD.

2.6. MECHANISMS

2.6.1. Functional Description

2.6.2. Performances

2.7. PYROS

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

2.8.2. Removable Covers (Non-Flight Items)

2.8.3. Deployable Covers (Flight Items)

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

ARIANE 5 Concept

MIMR is a category A instrument (autonomous thermal control).

ARIANE 4 Concept

The reflector module is category A instrument (autonomous thermal control). The other electronics units which are accommodated inside the platform, are category B instruments.

The MIMR instrument modules and units are classified as :

Module / Unit	Category
Sensor Module	A
MCU	B
ICPU/F	B
LVPS	B

3.1.2. Thermal Control Philosophy

Normal Operation

Sensor Module is controlled by passive means.

All Category B units are controlled by the platform thermal control subsystem which uses passive thermal control.

Contingency Modes

During the contingency modes the instrument is switched off. The MIMR Sensor Module is maintained within its survival limits by heaters controlled by thermostats.

All category B units are maintained within its limits by the platform thermal control subsystem.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the MIMR units are defined in Tables 3.2/1 and 3.2/2. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C MIMR	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
Sensor Module					
MCU					
ICPU/F					
LVPS					

Table 3.2/1 : MIMR Unit Qualification Temperatures

Deg. C MIMR	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
Sensor Module					
MCU					
ICPU/F					
LVPS					

Table 3.2/2 : MIMR Unit Qualification Temperatures

Stability Requirements

There is no temperature stability requirements for the MIMR units.

3.2.2. Radiative Interface

Sensor Module : TBD.

The sides of the category B units are black painted to facilitate radiation exchange with the platform interior (TBC).

3.2.3. Heater Power Budgets

The heater power budgets for the MIMR units are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
Sensor Module				

The heater power concept is not applicable to Category B units.

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipation of the MIMR units are constant throughout the orbit and are :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
Sensor Module	0.0	82.5 TBC	82.5 TBC	0.0
MCU	0.0	70.0	70.0	0.0
ICPU/F A / B	0.0	10.5 / 0	10.5 / 0	0.0
LVPS A / B	0.0	8.0 / 0.0	8.0 / 0.0	0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the MIMR units for different cases are :

Category A Units

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
Sensor Module	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

Category B Units

Module / Unit	Operative Heat Transfer (Orbit Average, Watts)			
	Conductive Hot Case	Conductive Cold Case	Radiative Hot Case	Radiative Cold Case
MCU				
ICPU/F A / B				
LVPS A / B				

3.2.6. Thermo-Elastic Interface

The interfacing platform structure for all the MIMR units is aluminium honeycomb with CFRP skins, with a coefficient of thermal expansion of 2.0×10^{-6} / deg. C (TBC). The MIMR units are TBD.

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interfaces for the MIMR units is defined in the Mechanical Interface Control Drawing (TBD) and in § 2.2.3.

Thermal conductance : TBD.

Category B unit baseplate contact areas : TBD.

The calculated temperatures at the MIMR units conductive interfaces are TBD.

3.3.3. Radiative Interfaces

The external surfaces of the MIMR Sensor Module, and the thermal finishes used are given in the Thermal Interface Drawing TBD.

The exterior thermal finish of the Category B units is black paint.

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red
	BOL	EOL	Emittance

MIMR Material Thermo-Optical Properties

The radiative environmental temperatures for the MIMR units are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacities of the MIMR modules are TBD.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

3.4. THERMAL ENVIRONMENT CONDITIONS

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Input Voltage : 22-37 Volts DC unregulated

The following power buses are provided by the platform :
- equipment power bus, nominal and redundant
- equipment heater power bus, nominal and redundant (for non-operating modes)
- ICU (Instrument Control Unit) power bus, nominal and redundant
- ICU heater power bus, nominal and redundant (for non-operating modes)

ARIANE 5 Concept

Basic consumption : 190 W

ARIANE 4 Concept

Current consumption, i.e. including contingency :

Units	Redundancy	Operation
Reflector Module	-	82.5
MCU	Internal	70.0
ICPU/F	External	10.5
LVPS	External	8.0

TOTAL (Current) 171 W

4.2. COMMAND AND CONTROL INTERFACES

The command and control of the instrument is performed via the PLM OBDH bus.

MIMR ICU has a nominal and redundant connection to the OBDH via a DBU supplied by the platform.

In case of emergency, MIMR can receive the equipment switch off line (EQU SOL), nominal and redundant.

Deployment : TBD.

4.3 SCIENCE DATA INTERFACES

MIMR generates packetized measurement data, that are transferred to the PLM data handling subsystem via a nominal and redundant connection via low bit rate data interface.

The data transfer is constant with a 112 kbps.

4.4. HOUSEKEEPING TELEMETRY

Thermistor Interface :
- thermistor for equipment, nominal and redundant connection to the platform
- thermistor for ICU, nominal and redundant connection to the platform

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

For the ARIANE 4 version, for which MIMR is split in several units, MIMR is responsible for the provision of the inter MIMR unit harness.

5. EMC / RFC INTERFACE DESCRIPTION

RF Receiver Characteristics

The MIMR RF receiver has the following specified characteristics :

CF	BW	Sensitivity
6.80 GHz	200 MHz	-129 dBm
10.65 GHz	100 MHz	-130 dBm
18.70 GHz	200 MHz	-125 dBm
23.80 GHz	400 MHz	-122 dBm
36.50 GHz	1000 MHz	-119 dBm
89.0 GHz	5400 MHz	-112 dBm

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

Interaction with the thrusters shall be addressed.

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

9.1.2. Instrument Engineering Model (EM)

9.1.3. Instrument Proto-Flight Model (PFM)

9.1.4. Instrument Flight Model (FM)

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

MIMR is continuously on along the orbit (duty cycle : 100%).

Commissioning : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

No specific orbit knowledge requirement.

10.5. INSTRUMENT OPERATION MANUAL

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 5 years

Reliability : TBD

12. PROGRAMME AND SCHEDULE

Annex 1 : MIMR Torque Disturbance Budget

TELECOPIE/FAX

MATRA MARCONI SPACE

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Reference : MT/FX/AD/132.94 Date : 21.02.94	Copies : C. Biscans, JL. Dusquene, D. Pawlak Fax N° :
Cet envoi comprend (ce nombre inclut cette page) 5 pages This fascimile consists of (thus number includes this page) 5 pages	Si vous n'avez pas reçu clairement cet envoi, veuillez nous contacter par téléphone au : 62.24.77.02 If you don't receive legible copies of all pages, please telephone immediately : 62.24.77.02

- URGENT -

Objet: METOP - MIMR perturbation torques

Reference document : "MIMR Torque Disturbance Budget" PO-TN-ALS-MI-1012 02/12/93

Please find herewith a summary of MIMR perturbation torques that were defined in the reference document and that we have updated taking into account the new position of MIMR on the platform. Our intent is to use these values for METOP disturbances analyses.

Table 1 provide a summary of the disturbances as they were defined in the reference document. There are some discrepancies between the values provided in the reference document and our computations. Could you be so kind as to clarify these differences (the reference numbers refer to those in table 1):

(1) : with using the indicated values of Ss, Sd, a, d and ω in the equation related to Txy, we find a torque value equal to : 0.005 Nm.
But the reference document gives a torque value of : 0.011 Nm.

(2) : with using the indicated values of Ss, Sd, a, d and ω in the equation related to Txy, we find a torque value equal to : 0.047 Nm.
But the reference document gives a torque value of : 0.012 Nm.

(3) : Sd value indicated in this cell is in fact proportional to d value (equal to about 440*d) according to the reference document. This case is the only one that we have found to be function of the distance between MIMR CoG and platform CoG. Do similar cases exist among the Ss or Sd values of table 1, that we have forgotten ?

(This remark is important because if the value of the distance between MIMR CoG and platform CoG changes, then the concerned Ss or Sd values must change also.)

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Moreover, the distances (a,b,c) used in reference document to compute the unbalance effects given in table 1 is the distance between MIMR CoG and platform CoG. How do you take into account the distance between unbalance mass and MIMR CoG ?

Finally the platform configuration has changed, which modifies the impact of MIMR unbalances. The new values that we computed are summarized in table 2. They have been estimated using the following lever arm between MIMR unbalance mass and platform CoG.

- According to METOP configuration as defined today, the distance between platform CoG and MIMR reference point (indicated on figure 3) has been estimated to be :

  -4.4 m
  -1.4 m
  -0.4 m

- According to MIMR configuration, the distance between static unbalance and MIMR reference point has been estimated to be :

  0.6 m
  -0.7 m
  2.8 m

- Finally the lever arm between MIMR static unbalance and platform CoG is :

  a=-3.8 m
  b=-2.1 m
  c=2.4 m

If we take into account these values instead of those considered in the reference document (a=2m, b=3m, c=2m), we obtain a new table of the perturbation torque values (that you can find attached on table 2). Can we consider table 2 as the reference one ?

Our intent is to continue METOP disturbance analyses using MIMR disturbances as defined in table 2. Could you be so kind as to confirm that this table is correct and complete.

Best regards

H. Boithias

w (rad/s)	Ss (kg/mm)	Sd (kg/mm2)	Tx=Ty (Nm)	Tz (Nm)	
0,21			-	0,006	wheel motor torque (with frequency lock loop)
0,42			-	0,026	wheel motor torque (with phase lock loop)
1,36	4,00	700,	0,016	0,027	scan radial run out - constant bias (value : 0,004°)
1,92	0,45	523,	**0,005 (1)**	0,006	ramp up (effect of transients -> no additive to the other contr)
2,72	0,60	100,	0,010	0,016	thermal distortion (orbit) - total of periodic terms
+ 2,72	1,00	500,	0,019	0,027	platform body rate (0,02g) - total of short terms
+ 2,72	1,00	2000,	0,030	0,027	in-orbit balancing residual (mean) - constant bias
= 2,72	2,60	2600,	0,058	0,070	
2,72	3,70	-	-	0,10	balance mechanism actuator (coupling between actuation rate and scan rate (coriolis)) - constant bias - medium terms and transients
5,44	0,00	**1600 (2)**	**0,047 (3)**	-	scan axial run out - constant bias (value : 0,004mm)
19			0,03	0,15	flexible modes
28,27			-	0,112	scan motor torque (net scan torque)
222,	0,06	1,0	5,96	10,66	wheel axis wobbling - constant bias (value : 0,001°)
444,	0,02	3,1	8,50	14,22	wheel unbalance (worst case) - constant bias

distance between MIMR COG and platform COG : 2,00 m
b = 3,00 m --> d = racine(b*b+c*c) = 3.61 m
c = 2,00 m

Table 1: MIMR disturbances defined in the reference document

	w (rad/s)	Ss (kg/mm)	Sd (kg/mm2)	Tx (Nm)	Ty (Nm)	Tz (Nm)	
	0,21			-	-	0,006	wheel motor torque (with frequency lock loop)
	0,42			-	-	0,026	wheel motor torque (with phase lock loop)
	1,36	4,00	700.	0,029	0,029	0,024	scan radial run out - constant bias (value : 0,004°)
	1,92	0,45	523.	**0,008**	**0,008**	0,005	ramp up (effect of transients --> no additive to the other contr.)
	2,72	0,60	100.	0,018	0,018	0,014	thermal distortion (orbit) - total of periodic terms
+	2,72	1,00	500.	0,032	0,032	0,024	platform body rate (0,02g) - total of short terms
+	2,72	1,00	2000.	0,043	0,043	0,024	in-orbit balancing residual (mean) - constant bias
=	2,72	2,60	2600.	0,093	0,093	0,061	
	2,72	3,70	-	-	-	0,09	balance mechanism actuator (coupling between actuation rate and scan rate (coriolis)) - constant bias - medium terms and transients
	5,44	0,00	**1672.**	**0,049**	**0,049**	-	scan axial run out - constant bias (value : 0,004mm)
	19			0,03	0,03	0,15	flexible modes
	28,27			-	-	0,112	scan motor torque (net scan torque)
	222.	0,06	1,0	11,29	11,29	9,43	wheel axis wobbling - constant bias (value : 0,001°)
	444.	0,02	3,1	15,59	15,59	12,57	wheel unbalance (worst case) - constant bias

distance between MIMR COG and platform COG :

a= -3,80 m
b= -2,10 m
c= 2,40 m

--> d = racine(b*b+c*c) = 3,19 m

Table 2 : MIMR disturbances computed for the new platform configuration.

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

SCARAB

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the SCARAB Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with SCARAB responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

The Scanner for Radiation Budget (SCARAB) is a four channel cross track scanning radiometer. The four spectral ranges are realised using filters and pyro-electrical detectors. SCARAB measures in the spectral range from 0.5 to 12.5 µm. It determines the radiation budget of the Earth atmosphere system. The instrument swath is ± 48°55'.

Channel	Spectral Region (µm)	Remark
1	0.5 - 0.7	Visible
2	0.2 - 4.0	Solar
3	0.2 - 50.0	Total
4	10.5 - 12.5	Atmospheric window

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94, Iss. 2, dated Sept. 94

Reference Documentation

Scarab Data List
Ref. PO-ID-SFM-SB-1051 (MET0139), Dated September 1994, Draft C

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

SCARAB is composed of :

- an optical head including the four optics and detectors, the scanner mechanism, the detector proximity electronic and the calibration black bodies and lamps
- the radiometer and satellite interface electronics
- a pedestal (tubular mechanical structure) designed to allow field of view clearance and housing the electronics.

SCARAB consists of a single unit.

The Part Number and Identification Code of the SCARAB instrument are :

PART NO: TBD

ID CODE: TBD

The location of the labels giving these Part Numbers and Identification Codes are defined in the Mechanical Interface Control Drawing.

The total envelope of SCARAB is : L (Velocity) x W x H (Earth) 760 x 480 x 625 mm.

SCARAB does not have any deployable part.

2.1.2. Mechanical Interface Control Drawing

The SCARAB instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The SCARAB configuration is illustrated in Figure 2.1/1.

2.1.3. Mass Properties

Mass

The mass properties of the SCARAB instrument are given in the following table. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{SCARAB} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the F_{SCARAB} axes are the same as the Spacecraft Reference Frame Fs.

Module /Unit	**Basic Mass (± 6.0 kg, TBC)**	**Centre of Mass Location (± 5 mm)**		
		X_{SCARAB} (Sun)	Y_{SCARAB} (Anti-velocity)	Z_{SCARAB} (Zenith)
SCARAB	50.0 kg			

SCARAB Mass Properties

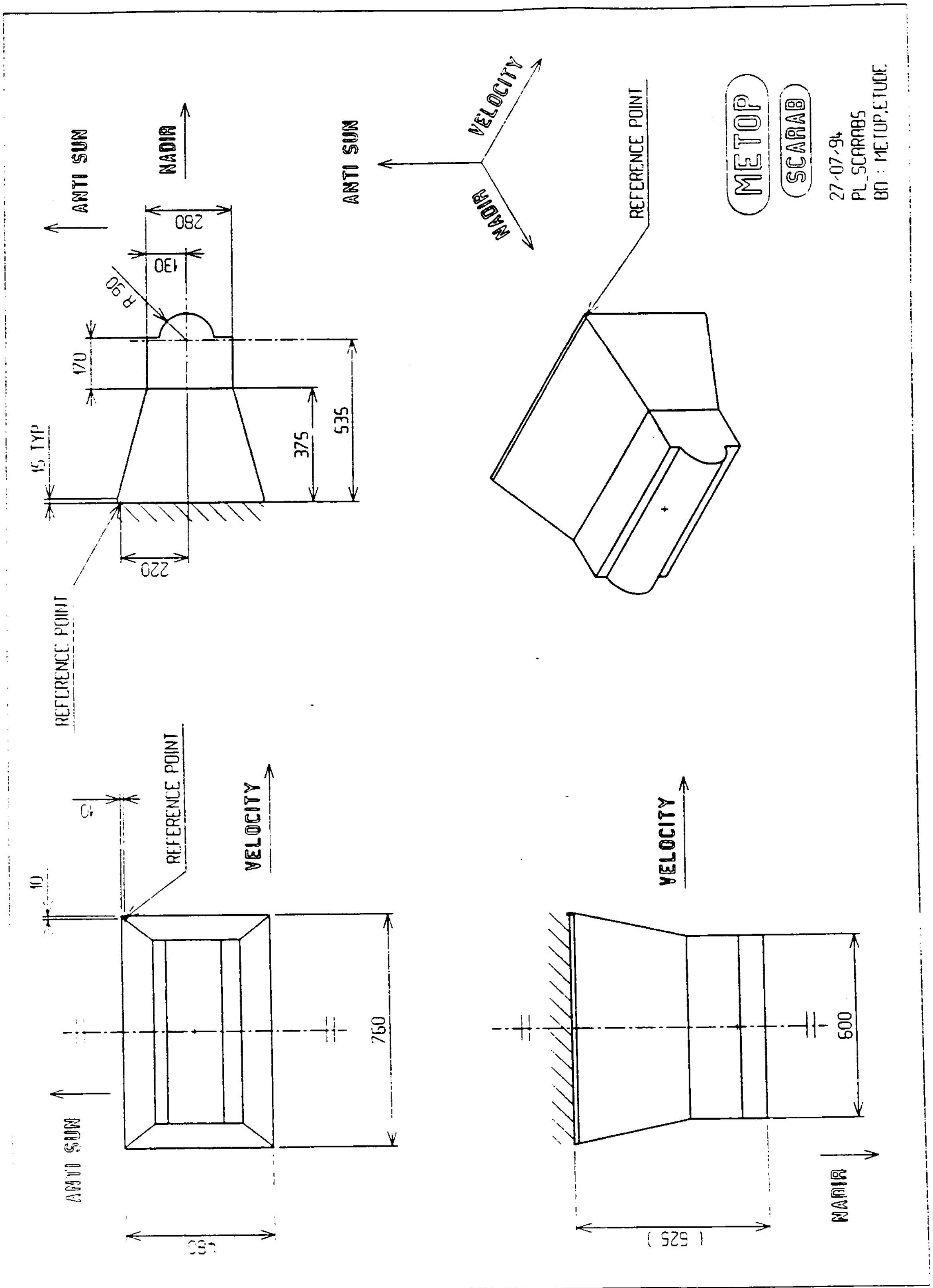


Figure 2.1/1 : SCARAB Configuration

Moments of Inertia

The SCARAB moments of inertia are as follows. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{SCARAB} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the F_{SCARAB} axes are the same as the Spacecraft Reference Frame Fs The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

Module /Unit	**Moments of Inertia ($kg.m^2$)**					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
SCARAB						

SCARAB Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

TBD

2.1.4.2. Continuous and Recurring Transient Events

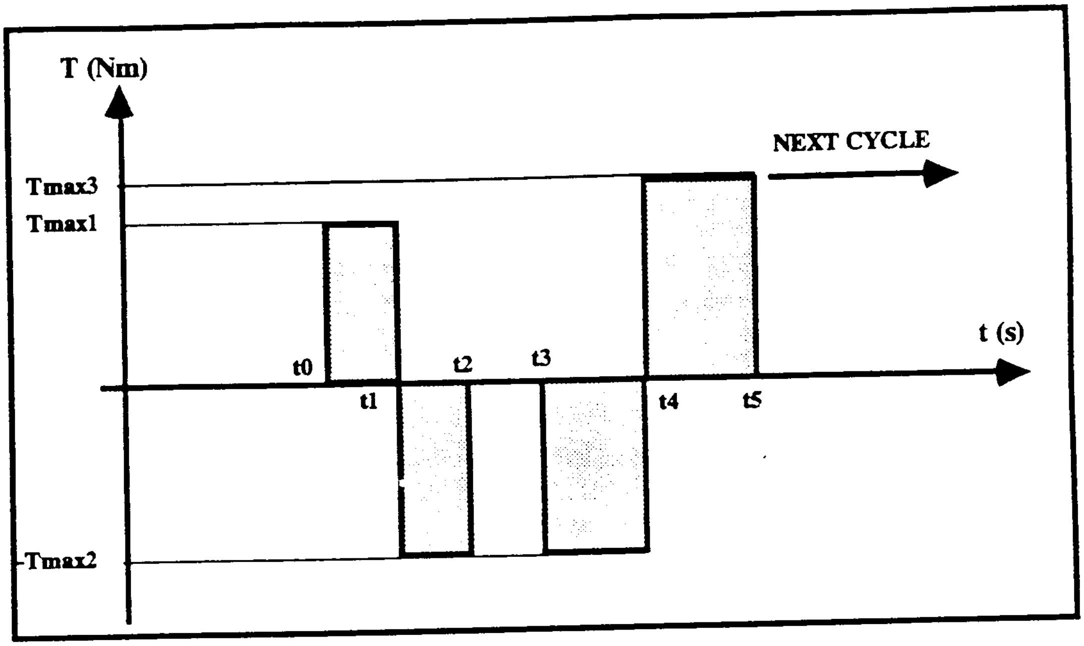
SCARAB scan mechanism induces reaction torques on the Y axis, as illustrated by the time measurement simulation outputs from Figure 2.1.4/1 for a 4 sec. scan cycle, and from Figure 2.1.4/2 for a 12 sec. (6+6) scan cycle.

The static and dynamic unbalance values on each axis are TBD.

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes



ENVELOPPE FOR SCARAB TORQUES DUE TO SCANNER MECHANISM

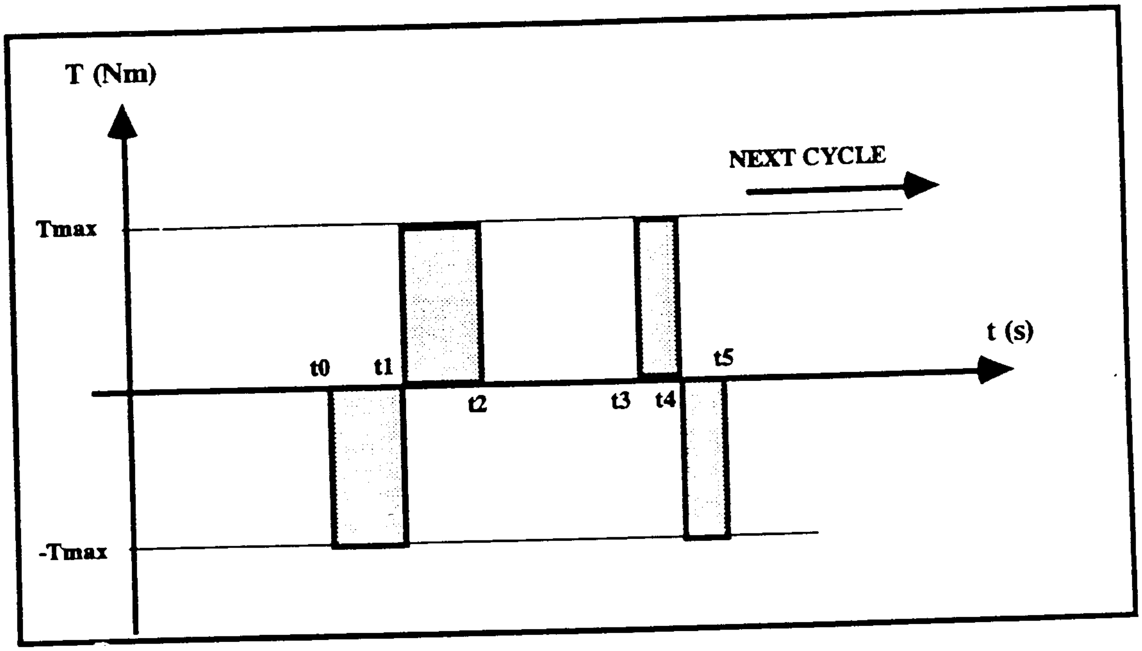
Type of operation	Repetition cycle	t_0 (sec.)	$t_1=t_0+dt_1$ dt_1 (sec.)	$t_2=t_1+dt_2$ dt_2 (sec.)	$t_3=t_2+dt_3$ dt_3 (sec.)	$t_4=t_3+dt_4$ dt_4 (sec.)	$t_5=t_4+dt_5$ dt_5 (sec.)
Across track scan	Nominal operation	2	0.3	0.35	0.35	0.5	0.55

Direction of torque around Y_s :	T_{max1} (Nm) :	0.13
	T_{max2} (Nm) :	0.156
	T_{max3} (Nm) :	0.17

Angular momentum integrated over any 0.2 sec. period (Nms) : 0.05

The specifications given for dt_1, dt_2, dt_3, dt_4, T_{max} and angular momentum are the maximum allowable values.

Figure 2.1.4/1 : Reaction Torques Due to SCARAB Scan Units
4 Second Scan Cycle



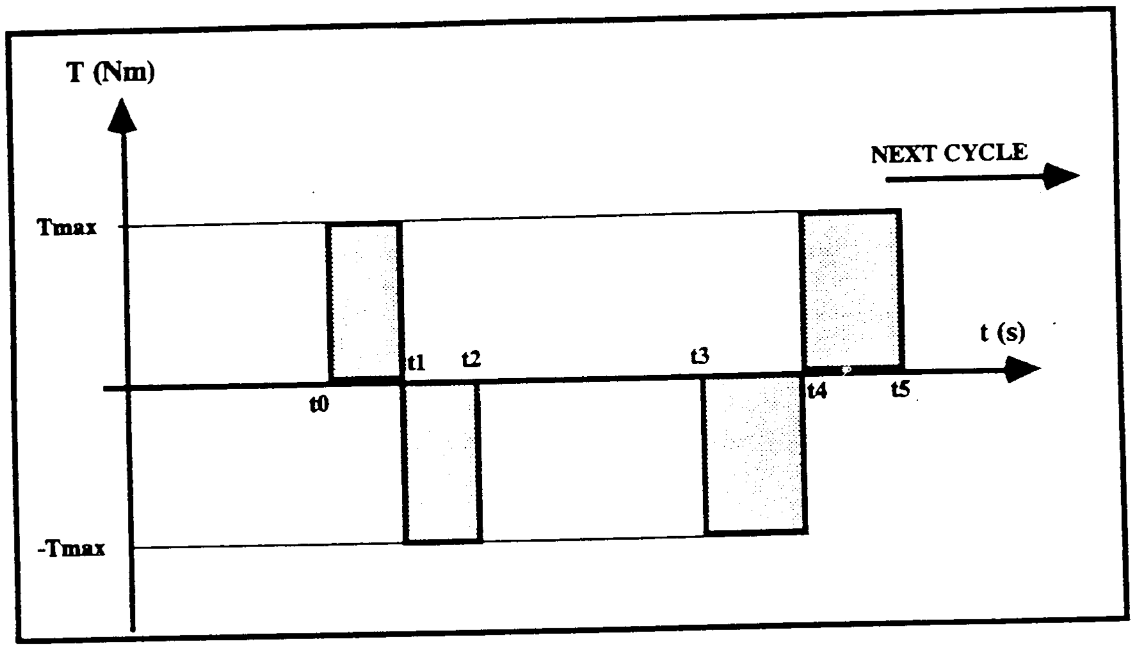
ENVELOPPE FOR SCARAB TORQUES DUE TO SCANNER MECHANISM
(Scan type SP)

Type of operation	Repetition cycle	t_0 (sec.)	$t_1=t_0+dt_1$ dt_1 (sec.)	$t_2=t_1+dt_2$ dt_2 (sec.)	$t_3=t_2+dt_3$ dt_3 (sec.)	$t_4=t_3+dt_4$ dt_4 (sec.)	$t_5=t_4+dt_5$ dt_5 (sec.)
Across track scan	Nominal operation	3.2	0.5	0.5	1.4	0.2	0.2

Direction of torque around Y_s : T_{max} (Nm) : 0.10

The specifications given for dt_1, dt_2, dt_3, dt_4, T_{max} and angular momentum are the maximum allowable values.

Figure 2.1.4/2 : Reaction Torques Due to SCARAB Scan Units
6 Second Scan Cycle - First Part



ENVELOPPE FOR SCARAB TORQUES DUE TO SCANNER MECHANISM
(Scan type L2/BBS)

Type of operation	Repetition cycle	t_o (sec.)	$t_1=t_0+dt_1$ dt_1 (sec.)	$t_2=t_1+dt_2$ dt_2 (sec.)	$t_3=t_2+dt_3$ dt_3 (sec.)	$t_4=t_3+dt_4$ dt_4 (sec.)	$t_5=t_4+dt_5$ dt_5 (sec.)
Across track scan	Nominal operation	3.2	0.3	0.3	1.1	0.5	0.6

Direction of torque around Y_s : T_{max} (Nm) : 0.10

The specifications given for dt_1, dt_2, dt_3, dt_4, T_{max} and angular momentum are the maximum allowable values.

Figure 2.1.4/2 : Reaction Torques Due to SCARAB Scan Units
6 Second Scan Cycle - Second Part

2.1.5. Field of View Definition

SCARAB boresight is defined as the nadir direction. The instrument field of view definition is :

- vertex (Cf. drawing)
- Spacecraft provision :
    - cross-track scan plane : from 83 deg. anti-Sun-wards to 65 deg. Sunwards.

      This is the general envelope for ± 65 deg. scanning and + 83 deg. for anti-Sun calibration.
    - Orbit plane : ± 7.0 deg.

SCARAB field of view is illustrated in Figure 2.1.5/1.

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The SCARAB instrument is mounted to the platform using 20 (TBC) M5 or M6 bolts.

The bolt size, length and torque required to mount the instrument are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
SCARAB				20

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for SCARAB is given in the Mechanical Interface Control Drawing, TBD.

2.2.3. Mounting Surfaces

SCARAB is mounted on its +Z side. The flatness of the mounting surface does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD μm. Each mounting foot has an area of TBD mm^2.

2.2.4. Materials

The material of the SCARAB interface is aluminium alloy, TBD. The PLM is an aluminium honeycomb panel with CFRP facing skins.

2.2.5. Interface Loads

The calculated interface loads induced by the SCARAB instrument are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
SCARAB				

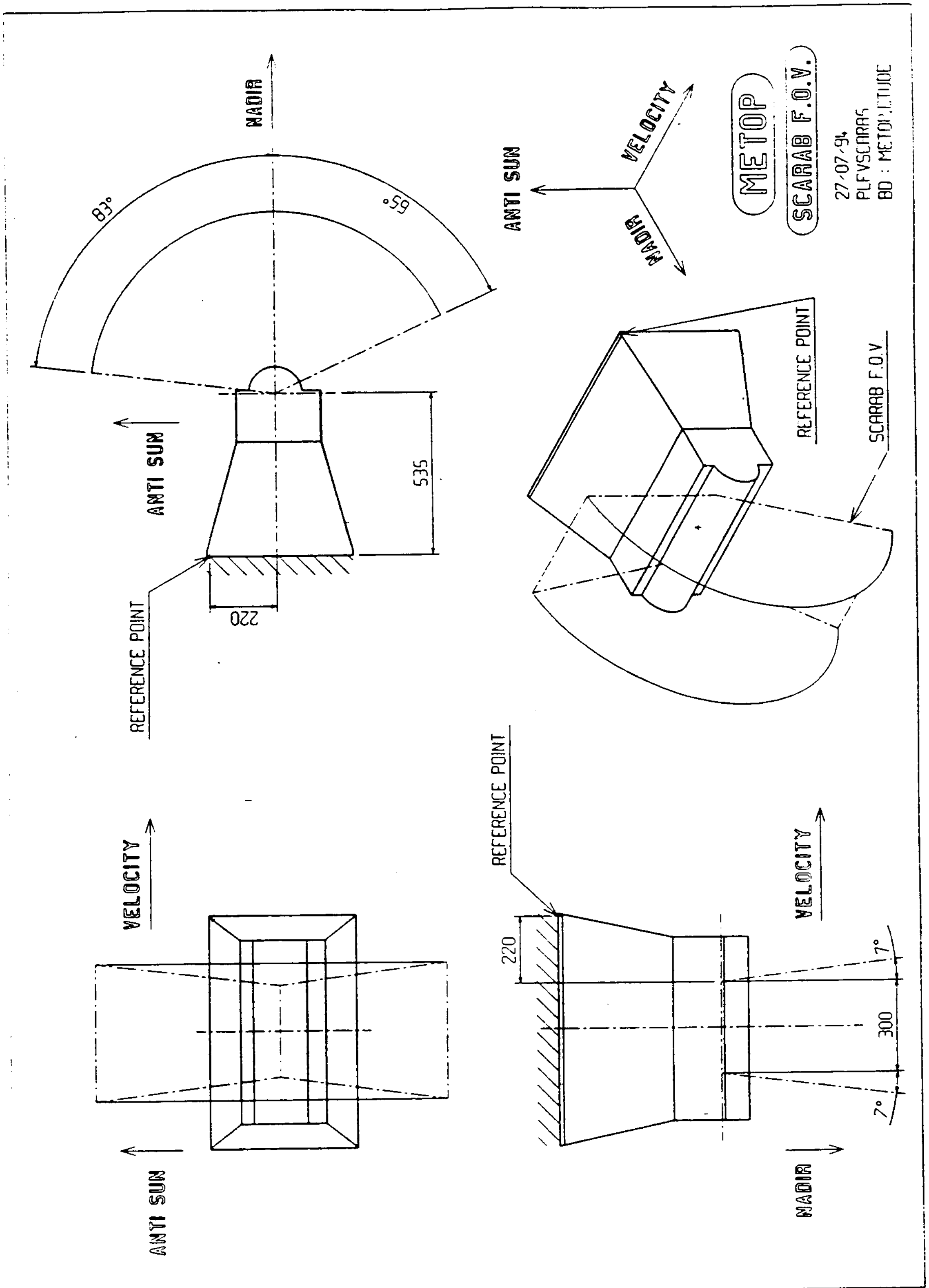


Figure 2.1.5/1 : SCARAB Field of View

2.2.6. Accessibility

SCARAB connectors are TBD.

2.2.7. Grounding Point

The location of the grounding points on the SCARAB instrument are defined in TBD.

2.3. POINTING

The pointing requirements for the SCARAB instrument are expressed at the Instrument Mounting Interface Reference Frame F_{SCARAB} .

Absolute Pointing Error (Accuracy) :	TBD deg. (3σ)
Absolute Measurement Error (Knowledge) :	TBD deg. (3σ)
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical Interface Control Drawing, TBD. The cube has TBD alignment surfaces of size TBD mm^2 which are viewed from TBD.

The cube shall be covered with a cover in accordance with TBD prior to launch

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

There is no co-alignment requirement for SCARAB.

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD.

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD. The first natural frequency of the SCARAB instrument is 123 Hz (TBC), this value having been established by analysis.

As this frequency is above the 100 Hz limit, no mechanical interface model is required.

2.6. MECHANISMS

2.6.1. Functional Description

SCARAB scan mechanism : TBD

2.6.2. Performances

2.7. PYROS

None.

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

2.8.2. Removable Covers (Non-Flight Items)

2.8.3. Deployable Covers (Flight Items)

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

SCARAB is a Category A instrument : it is thermally insulated from the platform and its internal heat is dissipated by radiation.

3.1.1. Category

The instrument thermal design is largely passive. Present requirements are ± 0.1 K for the black body simulator of the calibration module and ± 5 K for the optical head scan module. Heaters are used to control the electronics temperature long term variation within control ± 5 K.

3.1.2. Thermal Control Philosophy

Normal Operation

SCARAB thermal control is autonomous with dedicated radiators on the instrument sides (passive design).

Contingency Modes

During the contingency modes the instrument is switched off. The temperature of SCARAB will be maintained within its survival limits by survival heaters which are controlled using thermostats.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the SCARAB instrument are defined below. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C SCARAB	Operation		Non-Operation		Switch-On
	Min.	Max.	Min.	Max.	Min.
Acceptance					
Qualification					

Stability Requirements

There is no stability requirement for SCARAB.

3.2.2. Radiative Interface

The SCARAB passive radiator areas and the thermal views to space are given below :

Radiator Face	Area (m^2)	Required View Factor	Calculated View Factor	Calculated Gebhart
- X	TBD			
+ Y	TBD			

SCARAB Radiator Areas and Thermal Fields of View

3.2.3. Heater Power Budgets

The heater power budgets for the SCARAB instrument are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
SCARAB				

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipation of the SCARAB instrument is constant throughout the orbit and is :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
SCARAB	N/A			0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the SCARAB instrument for different cases are :

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
SCARAB	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

3.2.6. Thermo-Elastic Interface

The SCARAB instrument has an aluminium interface with a coefficient of thermal expansion of 25×10^{-6} / deg. C (TBC). The PLM mounting panel is aluminium honeycomb with CFRP skins with a coefficient of thermal expansion of 2.0×10^{-6} / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interface is the instrument baseplate which is defined in the Mechanical Interface Control Drawing (TBD), and in § 2.2.3.

The total thermal conductance between the SCARAB instrument and the PLC is TBD W/K.

The calculated temperatures at the SCARAB conductive interfaces are given in TBD.

3.3.3. Radiative Interfaces

The external surfaces of the SCARAB instrument, and the finishes used are given in the Thermal Interface Drawing (TBD).

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red Emittance
	BOL	EOL	

SCARAB Material Thermo-Optical Properties

The radiative environmental temperatures for SCARAB are TBD.

3.3.4. Thermal Heat Capacity

The thermal heat capacity of SCARAB is TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

3.4. THERMAL ENVIRONMENT CONDITIONS

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Input Voltage : 22-37 Volts DC unregulated

The following power buses are provided by the platform :
- equipment power bus, nominal and redundant
- equipment heater power bus, nominal and redundant (for non-operating modes)
- ICU (Instrument Control Unit) power bus, nominal and redundant
- ICU heater power bus, nominal and redundant (for non-operating modes)

The orbital nominal power consumption, with margin, is 75 W (current power consumption).

4.2. COMMAND AND CONTROL INTERFACES

The command and control of the instrument is performed via the PLM OBDH bus.

SCARAB ICU has a nominal and redundant connection to the OBDH via a DBU supplied by the platform. Note that the SCARAB ICU is shared with GOME.

In case of emergency, SCARAB can receive the following signals :
- equipment switch off line (EQU SOL), nominal and redundant
- depointing signal line (DSL), nominal and redundant

4.3 SCIENCE DATA INTERFACES

SCARAB generates packetized measurement data, that are transferred to the PLM data handling subsystem via a nominal and redundant connection via low bit rate data interface.

The data transfer is constant with a 3 kbps rate.

4.4. HOUSEKEEPING TELEMETRY

Thermistor Interface :
- thermistor for equipment, nominal and redundant connection to the platform
- thermistor for ICU, nominal and redundant connection to the platform

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCRIPTION

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.3.1. Quasi-Static Test

7.2.3.2. Dynamic Model Validation

N/A (SCARAB first natural frequency is above 100 Hz).

7.2.3.3. Vibration Tests

7.2.3.4. Acoustic Test

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

9.1.2. Instrument Engineering Model (EM)

9.1.3. Instrument Proto-Flight Model (PFM)

9.1.4. Instrument Flight Model (FM)

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

SCARAB is continuously on along the orbit (duty cycle : 100%).

Commissioning and calibration : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

10.5. INSTRUMENT OPERATION MANUAL

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 5 years

Reliability : 0.8 over 4 years

12. PROGRAMME AND SCHEDULE

INSTRUMENT INTERFACE CONTROL DOCUMENT (ICD) OUTLINE

GOME

CONTENTS

1. GENERAL

1.1. PURPOSE OF THE DOCUMENT

This document is the GOME Instrument Interface Control Document Outline. It deals with interface definition from the instrument to the METOP platform and with GOME responses to the generic METOP General Instrument Interface Control Document (GICD).

1.2. INSTRUMENT PRESENTATION

The Global Ozone Monitoring Experiment (GOME) is a nadir-viewing spectrometer which will observe solar radiation transmitted or scattered from the Earth atmosphere or from its surface. The recorded spectra will be used to derive a detailed picture of the atmosphere content and profile of ozone, nitrogen dioxide, water vapour, oxygen / oxygen dimmer, bromine oxide and other gases.

GOME instantaneous field of view is 40 km x 2 km, equivalent to 2.8 deg. x 0.14 deg. The instrument uses a scanning mirror which scans across the satellite track. With ± 31 deg. scan, global coverage can be achieved within 3 days.

Instrument performances is hereafter listed.

Band	Wavelength (mm)	Pixel Resolution (mm)	Spectral Resolution (mm)
1A	240 - 268	0.11	0.22
1B	268 - 295		
2A	290 - 312	0.12	0.24
2B	312 - 405		
3	400 - 605	0.2	0.4
4	590 - 790	0.2	0.4

Global Ozone Monitoring Experiment Characteristics

1.3. APPLICABLE AND REFERENCE DOCUMENTATION

Applicable Documentation

General Instrument Interface Control Document - GICD
Ref. MMS/MET/SPE/JLD/159.94. Iss. 2, dated Sept. 94

2. MECHANICAL INTERFACE DESCRIPTION

2.1. INSTRUMENT PHYSICAL CHARACTERISTICS

2.1.1. Module / Unit Identification

GOME consists of a single unit.

The Part Number and Identification Code of the GOME instrument are :

PART NO: TBD

ID CODE: TBD

The location of the labels giving these Part Numbers and Identification Codes are defined in the Mechanical Interface Control Drawing.

The total envelope of GOME is : L (Velocity) x W x H (Earth) 468 x 741 x 647 mm.

GOME does not have any deployable part.

2.1.2. Mechanical Interface Control Drawing

The GOME instrument configuration and mechanical interfaces are given in the Mechanical Interface Control Drawing, TBD.

The GOME configuration is illustrated in Figure 2.1/1.

2.1.3. Mass Properties

Mass

The mass properties of the GOME instrument are given in the following table. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{GOME} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the F_{GOME} axes are the same as the Spacecraft Reference Frame Fs.

Module /Unit	Basic Mass (± 1.0 kg, TBC)	Centre of Mass Location (± 5 mm)		
		X_{GOME} (Sun)	Y_{GOME} (Anti-velocity)	Z_{GOME} (Zenith)
GOME	56.0 kg			

GOME Mass Properties

Moments of Inertia

The GOME moments of inertia are as follows. The co-ordinate system used is the Instrument Mounting Interface Reference Frame, F_{GOME} , with the origin being at the reference mounting hole location as defined in the Mechanical Interface Control Drawing, TBD. The directions of the F_{GOME} axes are the same as the Spacecraft Reference Frame Fs. The accuracy of these values is within TBD % of the total instrument moment of inertia for each axis.

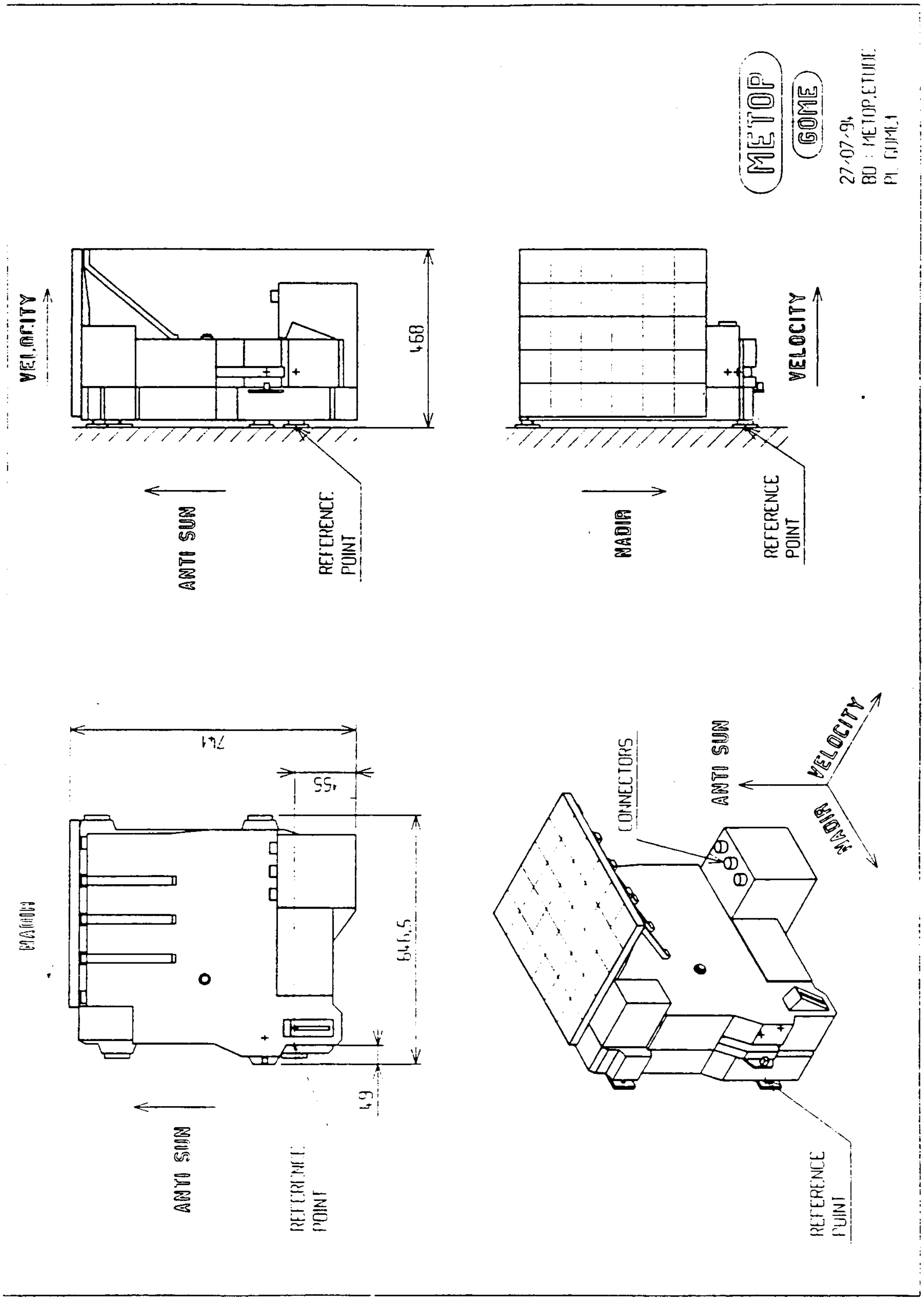


Figure 2.1/1 : GOME Configuration

Module /Unit	Moments of Inertia ($kg.m^2$)					
	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
GOME						

GOME Moments of Inertia

2.1.4. Instrument Induced Disturbances

2.1.4.1. Non Recurring Transient Events

TBD

2.1.4.2. Continuous and Recurring Transient Events

The instrument has an optical scan mirror that rotates along the Y axis. The generated peak torque and angular momentum amplitude are respectively 0.02 Nm and 4E-5 Nms.

The frequency content and / or time measurement plot is TBD.

The static and dynamic unbalance values on each axis are TBD.

Transient : TBD

2.1.4.3. Induced Disturbance Torque Effect

2.1.4.4. Flexible Modes

2.1.5. Field of View Definition

GOME field of view is illustrated in Figure 2.1.5/1.

Nadir Field of View

GOME boresight is defined as the nadir direction. The instrument field of view definition is :

- vertex (Cf. drawing)

  The beam width is 26 mm (TBC).

- Spacecraft provision :

  - cross-track scan plane : from 85 deg. anti-Sun-wards to 52 deg. Sunwards.

    This is the general envelope for ± 52 deg. scanning and + 85 deg. for anti-Sun calibration.

  - Orbit plane : ± 0 deg. (included in the vertex definition)

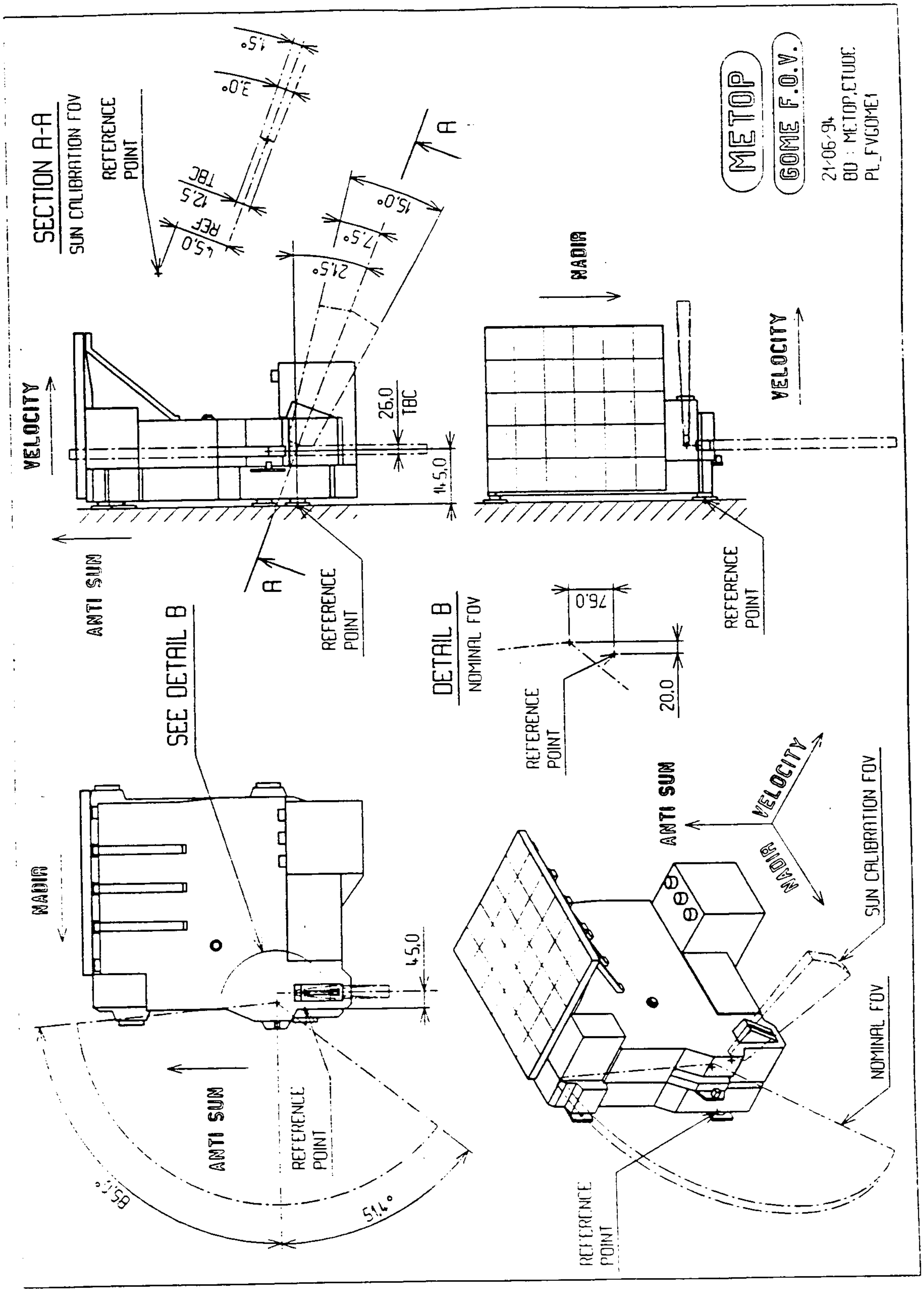


Figure 2.1.5/1 : GOME Field of View

Sun Calibration Field of View

GOME boresight is defined as a rotation of 21.5 deg. around the nadir axis (-Z) of the velocity (-Y) axis, towards the Sun direction. The instrument field of view definition is :

- vertex (Cf. drawing)

- Spacecraft provision :

  - ± 7.5 deg. in the XY plane.
  - ± 1.5 deg. in the boresight / Z plane.

This Sun calibration field of view shall adjusted to the METOP orbit.

2.2. INSTRUMENT MOUNTING ATTACHMENTS

2.2.1. Method

The GOME instrument is mounted to the platform using TBD bolts.

The bolt size, length and torque required to mount the instrument are :

Module / Unit	Bolt Size	Length (mm)	Torque (Nm)	Quantity
GOME				

2.2.2. Reference Point (Hole)

The definition of the Reference Point / Hole for GOME is given in the Mechanical Interface Control Drawing, TBD.

2.2.3. Mounting Surfaces

GOME is mounted on its +Y side. The flatness of the mounting surface does not exceed TBD mm in 100 mm. The surface roughness of the mounting surfaces are TBD µm. Each mounting foot has an area of TBD mm^2.

2.2.4. Materials

The material of the GOME interface is aluminium alloy, TBD. The PLM is an aluminium honeycomb panel with CFRP facing skins.

2.2.5. Interface Loads

The calculated interface loads induced by the GOME instrument are :

Module / Unit	Shear (N)	Tension (N)	Compression (N)	Moment (Nm)
GOME				

2.2.6. Accessibility

GOME connectors are TBD.

2.2.7. Grounding Point

The location of the grounding points on the GOME instrument are defined in TBD.

2.3. POINTING

The pointing requirements for the GOME instrument are expressed at the Instrument Mounting Interface Reference Frame F_{GOME} .

Absolute Pointing Error (Accuracy) :	TBD deg. (3σ)
Absolute Measurement Error (Knowledge) :	TBD deg. (3σ)
Absolute Rate Error (Rate) :	± 0.005 deg./sec. (3σ)

2.4. ALIGNMENT

2.4.1. Optical Reference Cube

The position of the Optical Reference Cube is given in the Mechanical Interface Control Drawing, TBD. The cube has TBD alignment surfaces of size TBD mm^2 which are viewed from TBD.

The cube shall be covered with a cover in accordance with TBD prior to launch

2.4.2. Alignment Procedure

2.4.3. Co-Alignment

There is no co-alignment requirement for GOME.

2.5. STRUCTURAL DESIGN

2.5.1 Limit Loads

The structural design analyses are TBD.

2.5.2. Quasi-Static Design Loads

2.5.3. Safety Factors

The calculated safety factors are TBD.

2.5.4. Dynamic Characteristics and Structural Mathematical Model

The structural dynamic analyses are reported in TBD.

2.6. MECHANISMS

2.6.1. Functional Description

GOME scan mechanism : TBD

2.6.2. Performances

2.7. PYROS

None.

2.8. INSTRUMENT APERTURE COVERS

2.8.1. Sensor Covers

2.8.2. Removable Covers (Non-Flight Items)

2.8.3. Deployable Covers (Flight Items)

3. THERMAL INTERFACE DESCRIPTION

3.1. INSTRUMENT THERMAL CONTROL CONCEPT

3.1.1. Category

GOME is a Category A instrument. Its thermal control is autonomous with dedicated radiators on the instrument sides.

3.1.2. Thermal Control Philosophy

Normal Operation

Passive concept using radiators (TBD).

Contingency Modes

During the contingency modes the instrument is switched off. The temperature of GOME will be maintained within its survival limits by survival heaters which are controlled using thermostats.

3.2. INSTRUMENT TEMPERATURE REQUIREMENTS AND THERMAL CONTROL BUDGETS

3.2.1. Temperature at Conductive Interface

Temperature Ranges

The operating, non-operating and switch-on temperatures for the GOME instrument are defined below. The Temperature Reference Point at which these temperatures apply is defined in TBD.

Deg. C	Operation		Non-Operation		Switch-On
GOME	Min.	Max.	Min.	Max.	Min.
Acceptance					
Qualification					

Stability Requirements

There is no stability requirement for GOME.

3.2.2. Radiative Interface

The GOME passive radiator areas and the thermal views to space are given below :

Radiator Face	Area (m^2)	Required View Factor	Calculated View Factor	Calculated Gebhart
- X	TBD			
- Z	TBD			

GOME Radiator Areas and Thermal Fields of View

3.2.3. Heater Power Budgets

The heater power budgets for the GOME instrument are :

Module /Unit	Heater Power Budget (Watts)			
	Operating Hot Case	Operating Cold Case	Off Cold Case	Off Safe Mode
GOME				

The resistance of the heaters is TBD.

3.2.4. Instrument Thermal Dissipation

The dissipation of the GOME instrument is constant throughout the orbit and is :

Module /Unit	Thermal Dissipation (Watts)			
	Operating Stand-by	Operating	Orbital Average	Contingency / Safe Mode
GOME	N/A	42 (TBC)	42 (TBC)	0.0

3.2.5. Heat Exchange Budgets

The calculated heat transfer between the platform and the GOME instrument for different cases are :

Module /Unit	Conductive Heat Transfer (Orbit Average, Watts)			
	Operating Hot Case	Operating Cold Case	Off Hot Case	Off Cold Case
GOME	<5 (TBC)	<5 (TBC)	<5 (TBC)	<5 (TBC)

3.2.6. Thermo-Elastic Interface

The GOME instrument has an aluminium interface with a coefficient of thermal expansion of 25×10^{-6} / deg. C (TBC). The PLM mounting panel is aluminium honeycomb with CFRP skins with a coefficient of thermal expansion of 2.0×10^{-6} / deg. C (TBC).

3.3. THERMAL INTERFACES

3.3.1. Thermal Interface Drawing

The thermal interfaces are defined in Thermal Interface Drawing, TBD.

3.3.2. Conductive Interfaces

The conductive interface is the instrument baseplate which is defined in the Mechanical Interface Control Drawing (TBD), and in § 2.2.3.

The total thermal conductance between the GOME instrument and the PLC is TBD W/K.

The calculated temperatures at the GOME conductive interfaces are given in TBD.

3.3.3. Radiative Interfaces

The external surfaces of the GOME instrument, and the finishes used are given in the Thermal Interface Drawing (TBD).

The thermo-optical properties of the finishes are given in the following table :

Surface / Material	Solar Absorptance		Infra-Red Emittance
	BOL	EOL	

GOME Material Thermo-Optical Properties

The radiative environmental temperatures for GOME are TBD.

3.3.6. Thermal Heat Capacity

The thermal heat capacity of GOME is TBD J/K.

3.3.5. Instrument Temperature Measurement

3.3.6. Thermal Mathematical Models

3.4. THERMAL ENVIRONMENT CONDITIONS

4. ELECTRICAL INTERFACE DESCRIPTION

4.1. POWER SUPPLY INTERFACES

Input Voltage : 22-37 Volts DC unregulated

The following power buses are provided by the platform :

- equipment power bus,
- equipment heater power bus (for non-operating modes)

These power lines are not redunded (TBC). For GOME ICU, since it is shared with SCARAB, power lines are described in the SCARAB ICD.

The total power consumption is 42 W in nominal operations (basic value).

4.2. COMMAND AND CONTROL INTERFACES

The command and control of the instrument is performed via the PLM OBDH bus.

GOME ICU is shared with SCARAB. Refer to SCARAB ICD for interface description.

In case of emergency, GOME can receive the equipment switch off line (EQU SOL, non redunded connection).

4.3 SCIENCE DATA INTERFACES

GOME generates packetized measurement data, that are transferred to the PLM data handling subsystem via a non redunded connection via low bit rate data interface.

The data transfer is constant with a 50 kbps rate.

4.4. HOUSEKEEPING TELEMETRY

Thermistor interface for equipment, non redunded connection to the platform

4.5. CONNECTORS AND HARNESS

4.5.1. Connectors Used at Spacecraft Interfaces

4.5.2. Connectors Used for Inter-Instrument Unit Interface

4.5.3. EMC Aspects

4.5.4. Cable Harness

5. EMC / RFC INTERFACE DESCRIPTION

6. CLEANLINESS AND SPACE ENVIRONMENT DESIGN CONSTRAINTS

6.1. CLEANLINESS REQUIREMENTS AND CONTAMINATION CONTROL

6.2. RADIATION ENVIRONMENT

6.2.1. Radiation Deposit Dose

6.2.2. Single Event Upset (SEU) and Latch-Up

6.3. SPACE ENVIRONMENT CONSTRAINTS

6.3.1. Meteoroid and Space Debris

6.3.2. Atomic Oxygen

7. INSTRUMENT DESIGN VERIFICATION DESCRIPTION

7.1. TESTING

7.2. TEST REQUIREMENTS

7.2.1. Electrical Functional Test Description

7.2.2. EMC Test Description

7.2.3. Mechanical and Structural Test Description

7.2.4. Thermal Test Description

8. GROUND SUPPORT EQUIPMENT DESCRIPTION

8.1. MECHANICAL GROUND SUPPORT EQUIPMENT

8.2. ELECTRICAL GROUND SUPPORT EQUIPMENT

9. GROUND OPERATION DESCRIPTION

9.1. MODEL PHILOSOPHY

9.1.1. Instrument Structural Model (SM)

9.1.2. Instrument Engineering Model (EM)

9.1.3. Instrument Proto-Flight Model (PFM)

9.1.4. Instrument Flight Model (FM)

9.1.5. Flight Spare Model

9.2. DELIVERY TO THE AIV SITE

9.3. INSTRUMENT INTEGRATION

9.4. PURGING REQUIREMENTS

9.5. GROUND ENVIRONMENTAL CONDITIONS

9.6. LAUNCH OPERATIONS

10. FLIGHT OPERATION DESCRIPTION

10.1. OVERVIEW

GOME is continuously on along the orbit (duty cycle : 100%).

Commissioning and calibration : TBD

10.2. ORBITAL PARAMETERS

10.2.1. Operational Orbit

10.2.2. Pointing Characteristics

10.3. MISSION OPERATION PHASES

10.4. OPERATION CONSTRAINTS AND RESPONSIBILITIES

10.4.1. Commandability

10.4.2. Observability

10.4.3. Information Provided by the Platform

10.5. INSTRUMENT OPERATION MANUAL

11. PRODUCT ASSURANCE AND RELIABILITY

Reliability

Design Lifetime : 5 years

Reliability : 0.8 over 4 years

12. PROGRAMME AND SCHEDULE